THE TELEGRAPHIC JOURNAL AND

Electrical Review.

VOL. XIX.—NO. 460.

THE VOYAGE OF THE VOLTA.

A NOTABLE event in the record of electrical achievements was that which took place last Monday, when the *Volta*, a launch fitted with a Reckenzaun motor and a set of E.P.S. storage cells, ventured across the English Channel, landed her occupants at Calais, reshipped them, and returned in safety to Dover. This remarkable trip may certainly be regarded as a great triumph for electric science, notwithstanding that the possibility of propelling boats by electricity had been amply demonstrated before. As our readers are aware, nearly four years ago the *Electricity* was run upon the Thames, and at various periods since other boats fitted with Mr. Reckenzaun's motors have been built, the most noteworthy being the launches constructed for the English and Italian Governments and the little electric boat attached to the Duke of Bedford's yacht *Northumbria*. It is within our knowledge that the *Volta* itself has made journeys up and down the river to distances of over 50 miles. But river trips attract comparatively little attention, and do not convey the impression which a sea voyage does of the value of any new kind of craft. The elements of danger are not so numerous, and there is less chance of prolonged inconvenience, for in the event of the exhaustion of the actuating force, whatever it might be, or of a breakdown of any sort, it would be a very simple matter to row or be towed ashore. As an illustration of our assumption that the ocean is much more formidable than the river where new means of transport are concerned, we may cite the case of steamboats, which were used with success on rivers for many years before anybody ventured across the seas in one. People who felt quite secure whilst the new boat confined its range to rivers, hesitated and calculated the prospects of failure when a trip to sea was proposed. This sounds a little curious in these days, when the other end of the world is not considered too far away for a steam voyage. Yet so it was. And the aim of the promoters of the *Volta's* voyage was to overcome this timidity in the case of electricity likewise. Once the trial has been made, and the ease and safety of the thing have been demonstrated, absolute faith will be placed in electric boats by "the general," and the only danger is that they will become a little too credulous and imbibe the belief that to-morrow we shall be flying across the raging main in huge electric vessels in which the detestable noise, heat, and dirt of the present day steam engines and their appurtenances will play no part. Despondingly and sorrowfully we say it, but the truth must be confessed: this roseate vision will not be realised in this or the next generation; in fact, so far away from present possibilities is its accomplishment that it seems to belong to the realm of the impossible.

A few facts anent the *Volta* may be of interest. She is steel built, measures 37 feet long by 6 feet 10 inches beam, and is fitted with a battery of 61 cells and a duplex Reckenzaun motor, that is, two motors carried on one driving shaft. By means of this motor the speed can be varied without affecting the accumulators, three speeds being obtained from it, namely, slow, medium, and fast. For the slow speed the motors are coupled in series, for the medium speed one motor only is used, while for the maximum speed the two motors are used in parallel. One switch only serves to regulate the speed, but a separate switch is used to reverse the motors, which are placed well aft, directly over the keel, and measure together 3 feet 10 inches long by 1 foot 9 inches wide and 12½ inches high over all. They weigh 730 lbs. and develop a maximum of 16 H.P. on the brake. The propeller is a three-bladed screw, 20 inches in diameter and 11 inches pitch, coupled direct to the motor shaft, whose revolutions are about 600 per minute at the slow speed and 1,000 per minute at full speed. The accumulators weigh about two tons, and are arranged along the keel of the vessel beneath a wood decking.

The *Volta* left Dover on Monday at 10.40 a.m. amidst bright sunshine; there was a slight wind and the tide was running strongly. The promoters of the trip were so thoroughly assured of the ability of the little vessel to cross and recross in safety, that they did not think it necessary to provide a boat of any kind to accompany her. She drifted with the tide a little eastward of the direct course on the outward journey, but arrived safely at Calais at 2.32 p.m. When about mid-channel an exciting incident occurred. Toms, the pilot, (who, by the way, is the same pilot who accompanied Capt. Webb in his memorable swim from Dover to Calais) espied what appeared to be a gull asleep upon the water. As a test of the noiselessness of the vessel it was determined to get as near the sleeping bird as possible. The attempt was so successful that one of the party was enabled to seize the bird by the neck before it became aware of the propinquity of its enemies. It turned out to be a fine specimen of the Solan goose, and measured 5 feet 11½ inches from tip to tip of its outspread wings The bird was taken alive to Dover, and next morning was killed in order that it might be stuffed.

A stay of perhaps three-quarters of an hour was made in Calais, and the return journey was embarked upon at 3.14 p.m., by which time the tide had turned, so that the boat drifted to the westward instead of to the east as when outward bound. Allowing for this tidal drift, it is computed that the distance actually accomplished by the *Volta* when she reached Dover once more, which she did at 7.27 p.m., was at least 54 statute miles. The total time of running, including that employed in clearing the harbour, was 8 hours 4½ minutes. The motors required no attention except in the shape of lubrication, and the switch handle was not touched except when necessary to start and stop at

Dover and Calais. The average current throughout was 27 ampères. The current at starting was 28 ampères, at which it remained constant right to Calais and half way back; but it was found to have dropped to 24 when Dover harbour was reached.

The object of this trip was, as we have said, to inspire confidence in the use of electro-motors, and to prove to a timid public that electricity possesses all the virtues requisite in boats designed for special purposes, such, for instance, as pleasure boats and launches, where such qualities as silence, safety, a reasonable speed, ease of management, absence of smoke or steam, and large space are appreciated. We should like to say here that with a well-constructed electric motor there is less risk of breakdown than with a steam engine, which has a large number of working parts against very few in the motor.

What somewhat surprises us is that Mr. Stephens and Mr. Reckenzaun put off from Dover with so small a number of passengers. The boat carried only ten persons, including the crew, whilst there was room for forty. The reason, we are told, why so few embarked was that those who came to see the boat were for the most part chary of trusting themselves on board for what they considered a venturesome trip. Amongst those who did demonstrate their faith in the little vessel were General Brine, R.E.; Mr. Perry F. Nursey, representing the *Times*; Mr. J. Godfrey, of the *New York Herald*; Mr. A. Reckenzaun, C.E.; and Mr. J. Stephens, of the firm of Stephens, Smith & Co., marine engineers. Several gentlemen, including representatives of the scientific press, journeyed to Dover to see the start and then crossed the Channel in the swift mail steamer *Victoria*, which left Dover later than the *Volta* and reached Calais before the latter. This incident illustrates the want of confidence even amongst those who ought to know better; but we trust the result of the venture has removed any doubts which may have existed as to the *Volta's* capabilities. We shall everlastingly regret that the unaccountable vagaries of a telegram prevented our taking part in this historical trip, which, although, perhaps, not in itself of paramount importance, will yet be regarded as marking a distinct epoch in the industrial applications of electricity. We offer our congratulations to the organisers of the voyage, Messrs. Stephens and Smith and Mr. Reckenzaun, upon the unqualified success which they achieved.

WELDING BY ELECTRICITY.

ONE of the most ingenious and widely applicable uses to which electricity can be applied, according to the view of the *Electrical World*, is that recently brought out by Prof. Elihu Thomson, the well-known electrician of the Thomson-Houston Electric Company. Heretofore, the manner in which joints have been made between two pieces of metal, especially if in the wire form, was such as to leave the joint thicker than and out of symmetry with the other part of the piece.

With the object of overcoming this difficulty, and to secure a good joint between wires without the application of solder, and to obtain an actual weld between two abutting ends, Mr. Thomson employs the electric current to excellent advantage.

Briefly stated, the new art of "electric welding" consists in bringing together the ends of the wires or bars, &c., to be joined, and then constituting the abutted ends and a slight portion of the wire or bar on each side of the joint the path for an electric current of great volume.

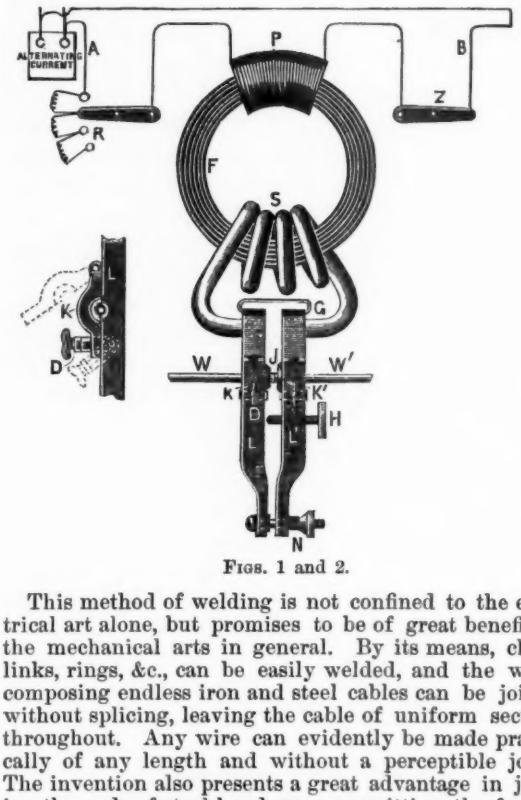
The manner in which this idea is put into practical operation is extremely simple, and will be readily understood by reference to the accompanying illustrations, figs. 1 and 2. As will be seen, wires from an alternating source of current are led to a coil, P, wound around one side of an iron ring, F, which forms the primary of a secondary generator. The secondary coil, S, consists of a few turns of heavy copper cable having an almost inappreciable electrical resistance. A resistance, R, is placed in circuit with the primary so as to vary the strength of the current, and a switch, Z, permits of rupturing it at will. The ends of the secondary coil are attached each to one of a pair of blocks, L, L′, of good conducting metal, which carry clamps for holding the wires in position, and for rapid manipulation they are hinged, as shown in fig. 2. A nut, N, and a compressed spring permit the arms to be drawn together.

The wires being brought into contact by gentle pressure, the current is allowed to pass, the ends of the wire fuse, and, being pressed together, form a perfect welded joint, which is nearly uniform in texture with the rest; and the wire treated can be bent, twisted, hammered and drawn without rupture.

By this method, wires of copper, brass, iron, steel, or German silver are easily welded, and no difficulty is experienced in joining German silver to steel or iron, or brass with iron, or many other different metals.

Of course, it is important that the wires shall be clean to ensure good contact, and though usually the joint is well formed without any flux, such as borax, there is no objection to its use in slight amount in certain cases.

The advantages which this method of welding presents over the usual manner of jointing must be evident. It enables the accomplishment in an easy manner of what was before very difficult or impracticable.



FIGS. 1 and 2.

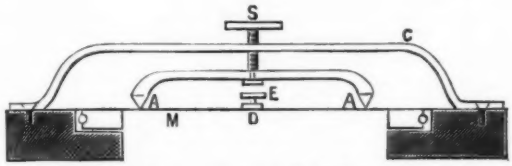
This method of welding is not confined to the electrical art alone, but promises to be of great benefit in the mechanical arts in general. By its means, chain links, rings, &c., can be easily welded, and the wires composing endless iron and steel cables can be joined without splicing, leaving the cable of uniform section throughout. Any wire can evidently be made practically of any length and without a perceptible joint. The invention also presents a great advantage in joining the ends of steel band saws, permitting the formation of joints without heating the metal to any considerable distance on each side of the joint, so that temper, elasticity and finish remain uninjured. Other applications will readily suggest themselves, and the invention must be looked upon as one of the most important of the recent applications of electricity.

From the easy manner in which even heterogeneous metals are joined by this process, it would appear that the passage of the current in the presence of heat puts the metal in a peculiarly favourable condition, so that it welds easily. Hence Mr. Thomson proposes, in the case of large pieces, where the current alone would be insufficient to engender a welding heat, to heat the pieces additionally by external means, the presence of the current acting so as to make the weld more perfect.

THE REIS TELEPHONE.

PROF. FRANCIS E. NIPHER writes in the *Electrical World* upon this well-worn subject as follows:—"It is conceded by all that Reis used his telephones to transmit the music of various instruments. Those who have had comparatively little experience with the Reis instrument have often been unable to make it do even this. After much experimenting with various forms of the Reis telephone, and with varied success, I was greatly impressed with a sentence in the letter of Reis to Ladd, given in Silvanus Thompson's book on the Reis telephone. I quote this sentence from memory: 'It would take me a long time to narrate my many failures, until I learned the proper dimensions of the parts, and the proper tension of the membrane.'

"It suddenly occurred to me that it was just here that Reis had touched the vital element involved in the successful working of his telephone. Acting on this idea I at once made an adjustment, by means of which the tension of the membrane could be varied at will. The device is shown in section in the accompanying



TENSION REGULATOR FOR REIS INSTRUMENT.

figure, in which *m* is the membrane, mounted on a brass ring in the usual manner. Above is a ring, A, A, terminating below in a knife-edge, in contact with the membrane. This ring is carried on a diametral bar, which is again supported on a swivel screw, S. The screw is mounted in a support, C, which is attached to the cover of the instrument. The working points are shown at D, E, in which E is either the angle-piece of the gravity instrument, or the spring of the bored-block form.

"By turning the screw the membrane can be adjusted to any required tension. The best membrane is the one recommended by Reis—the intestine of a hog. If any one who has failed to work a Reis telephone will try this improved form, he will find why he failed. He will probably find, as I did, that he had been working with too tight a membrane.

"With this device it is very easy to adjust the Reis telephone so that it will work at its best in transmitting musical sounds. It will then be found that the instrument will also best transmit articulate speech. Singing into it, 'not too loudly,' the listener hears the air and words. '*Any* sound will be transmitted, if strong enough to set the membrane into vibration.'

"After a little experience with the improved Reis, any one of ordinary skill can operate the common form. The essential thing is to get the proper tension of the membrane."

THE MARCHANT ENGINE.

IN our issue of July 30th last we gave a brief sketch of this steam engine, and expressed a hope that at a future date we should be enabled to give some particulars of its construction, and also some data as to its working capabilities, which for economy in consumption of fuel had been reported as unprecedented. The amount of fuel stated to have been consumed per horse-power hour appeared to engineers so fabulously small that many did not scruple to give their opinion that a mistake must have been made somewhere, or that the tests were observed through the usual roseate glasses of an enthusiastic inventor.

We have been anxious, therefore, to lay before our readers a few facts on which we believe they may rely.

Some tests which we have specially made, in conjunction with Mr. Reckenzaun, conclusively show that a horse-power-hour can be obtained with a consumption of considerably less than 1 lb. of coal; the results will be found tabulated below.

These tables represent runs of various duration, ranging from 1 hour and 20 minutes to a useful and sustained one of 6½ hours, in which latter trial a brake horse-power of 98·0 H.P. was developed, with an expenditure in fuel amounting to 77·54 lbs. of coal per hour, which gives 0·791 lbs. of coal per horse-power-hour. Favourable as this result is, it seems not at all improbable that a still more economical consumption can be obtained, the inventor not considering his engine to have been working under the best conditions. Mr. Marchant and Mr. William Downie, the managing director of the Marchant Engine Syndicate, were present during the whole of the above trial, and gave us every facility in pursuing our tests.

The engine is the same as that exhibited last year at the Inventions Exhibition, where, however, owing to defects in the boiler, few persons inspected it at work. It is constructed to give 100 H.P., and is of the compound surface-condensing marine type. Although in marine engines a certain amount of economy is due to high-pressure steam, to surface condensation, and the large ratio of expansion obtained in expanding the steam in several cylinders consecutively before reaching the condenser, the much enhanced efficiency of the Marchant engine, in comparison with that of the most approved form hitherto made, is to be found in the system whereby a large proportion of heat usually wasted is returned to the boiler.

The principle is one that has often been mooted but never before brought to a practical and successful issue. It consists in utilising the latent heat of the major portion of the steam passing through the cylinders, which steam is compressed into the feed water from the condenser and flung back to the boiler by a cushion or spring of air under considerable pressure.

In action the steam at its initial pressure passes from the boiler to the high pressure cylinder, from whence one-third of the steam is taken to the low pressure cylinder, expands, does its work, and is exhausted into the vacuum maintained in the condenser, converted into water, and finally is conducted to the pumps as feed water; the other two-thirds of steam on leaving the high pressure cylinder passes into another, is expanded at two-thirds the stroke, and having exerted its power proceeds to a pump, where it is again expanded. After this the two-thirds steam is compressed in the last pump into the one-third feed water; this latter process is carried on at the expense of engine power, which is exerted not only in forcing the steam into the feed water, but in compressing a cushion of air maintained at a proper pressure by means of air pumps; this cushion or air spring on the return stroke renders up its stored energy by pushing or returning the combined feed of steam and water back to the boiler.

The entire economical success of the engine rests on the proper action of this spring, and it was only by years of study and experiment that Mr. Marchant has been able to arrive at these results.

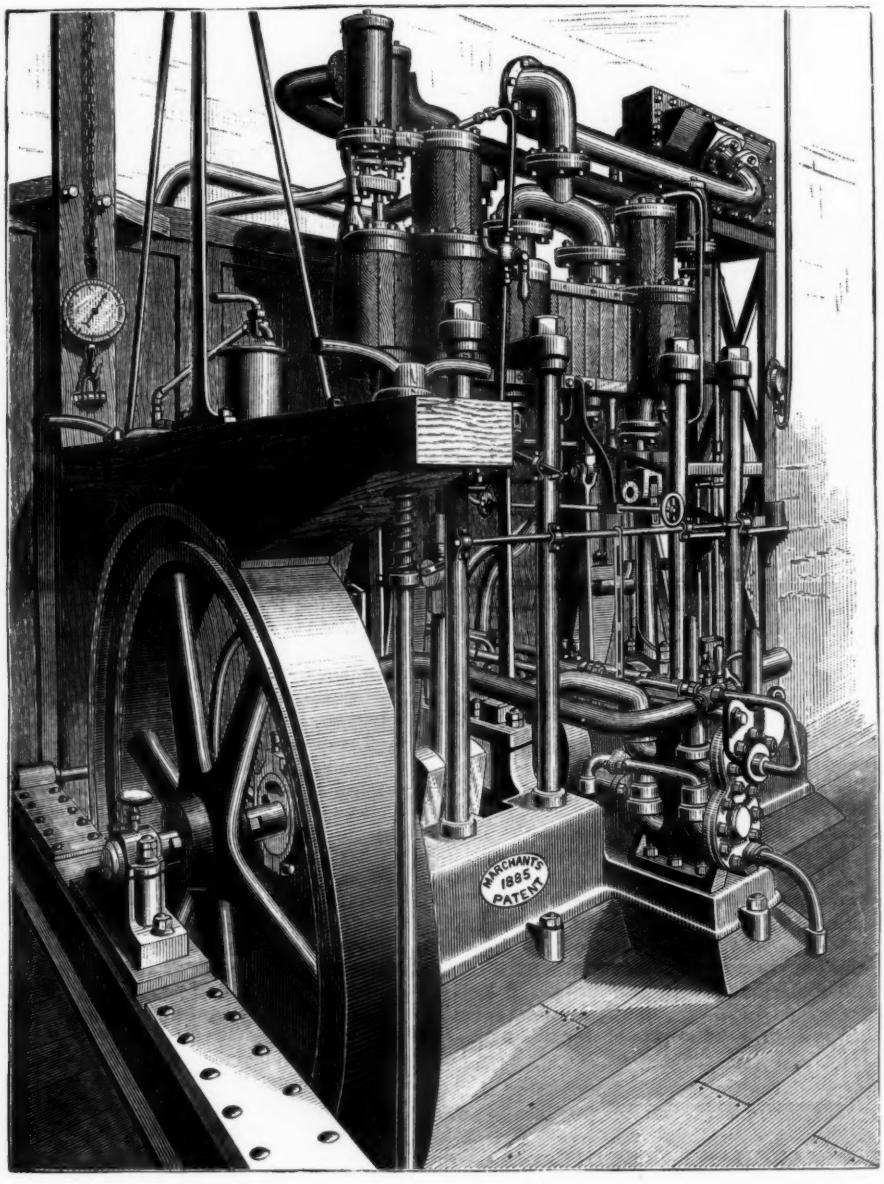
The absence of lubrication in all the cylinders causes the feed to be returned to boiler in a perfectly clean state, so there can be very little incrustation. The pressure, averaging about 225 lbs. per square inch, is not far in excess of some other engines already in use.

The annexed figure shows a perspective view of the engine, of which it gives a good general representation, as well as of the condenser. Attached to the fly-wheel will be seen the brake which has been used in the several tests that have been made. In the back ground at the right hand upper corner of the cut may be observed a square looking box elevated on trestles; this is the surface condenser, which, however, only occupies about one-sixteenth of the space usually devoted to that purpose in ordinary surface condensing engines. The cylinder, furnished with pressure chambers, in the

centre of the front ground frame work, is one of the pumps which maintains the steam feed.

As the object of our tests was to gain some knowledge of the engine and its stated merits as regards economy, we resolved upon a trial which should last some hours and might be looked upon as a normal run required in an ordinary every day case of electric lighting.

We considered about 6 hours sufficient for the purpose, and the total duration of the trial extended to 6½ hours. This 6½ hours' run we made without once stopping the engine, and during these hours we managed to take



other tests without interfering at all with the main run.

First we desired to find out the power given back by 1 cwt. of coal consumed in the furnaces, starting with a full boiler pressure and the engine permitted to run until the hundredweight was exhausted such time being terminated at next coaling. Table I. gives the data.

Then, again, we continued burning fuel till 3½ cwt. of coal had been fed to the furnaces, then allowing the steam to work the engine for some time longer. Table II. gives all the information respecting this.

Table III. explains the next test, which consisted in making up the fires again as quickly as possible with another hundredweight of coal, and utilising all available power by running sufficiently long to lower the steam pressure to about half its initial pressure; this test also represents a run after a defect, mentioned later on, had been remedied, with the result of obtaining an improved return per lb. of coal.

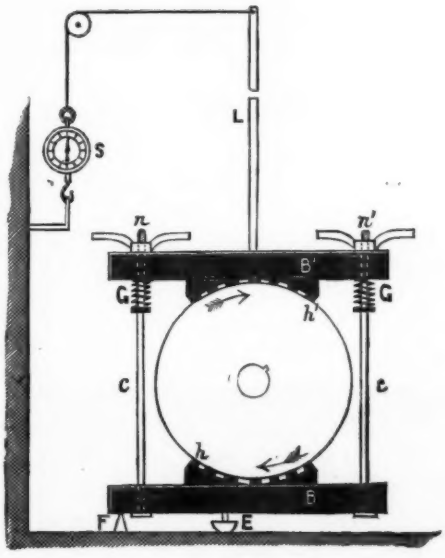
Table IV. tabulates the results of the entire 6½ hours, with an expenditure of 4½ cwt. of Welsh coal.

The measurements were carefully taken, many in duplicate, to insure accuracy. All the coal was weighed by a Salter's balance, which we afterwards tested for accuracy and found correct.

The Prony brake employed to measure the energy developed had a lever of 12 feet radius, with a chain working over a pulley registering the pull on a Salter's balance; this balance was found to be correct also. The brake was fitted to the flywheel. The weight of the chain over the pulley has been taken as 9 lbs., and accounted for in H.P. calculations. The horse-power is calculated by the number of revolutions of flywheel × (weight on balance + 9 lbs.) × constant ·00228 which is the useful power.

This dynamometer was a modification of the common pattern of brake, and was devised by Mr. Marchant as a means of getting rid of the heavy weight which would otherwise rest on the axle of the engine

when not running, the entire weight of the apparatus being 720 lbs; the accompanying diagram will explain its construction. The lower block, B, is supported by the rolling piece, E, which carries the whole of the brake when out of action, and the spiral springs, G, G, working against stops fixed to the bolts, *c*, *c*, help to raise the upper portion, B′, out of contact with the pulley. A stop, F, is placed under the lower bar on the scale side, so adjusted that, while the pointer on the Salter's balance, S, shall read from zero, the tension on the chain to lever, L, shall have no back play. The rolling block, E, is situated slightly to the scale side of a vertical line passing through the axle, and is wedged up against the surface of the pulley, sufficiently to ensure contact with the portion of the brake block marked *h*, and to prevent the whole weight of the instrument being thrown at any time suddenly on to the pulley. The fly nut, *n*, is only partially tightened up, the grip when required being effected by the opposite nut, *n′*; it is claimed that this ensures the clip being on the sides marked *h*, *h′*, which keeps the pull steady and minimises shocks from backward and forward vibrations of brake. Mr. Marchant contends that by the above arrangement, so far as is practicable, the pull of the clip should be shown by the spring balance without friction or weight of brake; also that the pull on the spring balance as exercised by the clip must show less than the engine power, and the regularity of the action leads him to infer that he has greatly got rid of friction which is extraneous to the clip, although of course some must exist.



The steam gauge was not adapted for making very correct readings, each small division on its dial registering 25 lbs. pressure, but this fact was not of much consequence as we were only desirous of testing the

TABLE I.

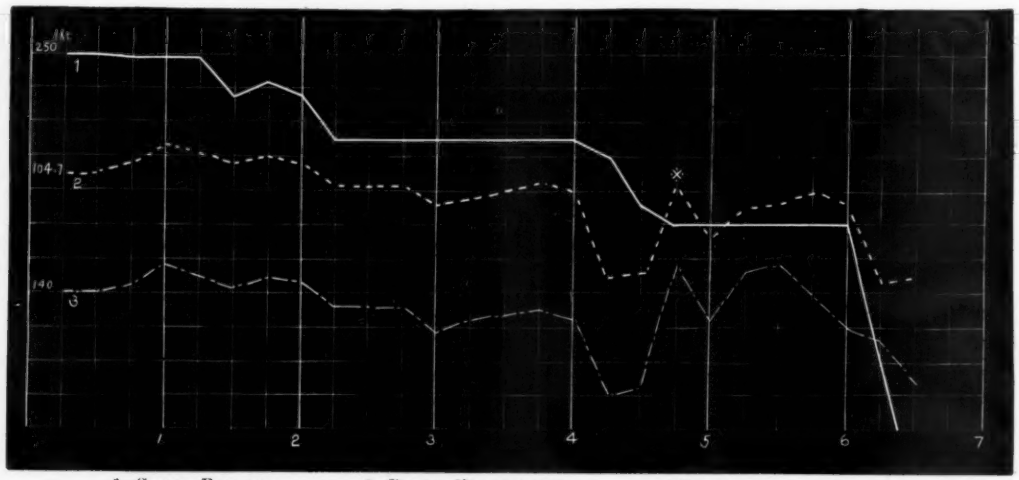
TEST.			PRESSURE, &c.		WORK.				CONSUMPTION OF FUEL.			REMARKS.
			Boiler.	Condenser.	Engine.	Brake.	Horse-power.		Welsh coal.			
No.	Time of taking test.	Duration of test in decimal hours.	Pressure per square inch in lbs.	Vacuum in inches.	Revolutions per minute.	Pull in lbs. on Salter's balance.	H.P. developed on brake at each test.	K Average H.P. on brake.	Total coal consumed in lbs.	W Coal consumed per hour in lbs.	$\frac{W}{K}$ Coal consumed per H.P. hour in lbs.	
	H. M.											
1	3 0	...	262	17	134	320	100·5	...	...	...	...	Coaled at 3h. 2m.
2	3 15	...	250	17	140	319	104·7					
3	3 30	...	250	16·5	140	318	104·4	...	...	...	...	Coaled both doors.
4	3 45	...	250	17·5	142	319	106·2	...	...	...	...	Coaled right door.
5	4 0	...	249	17	148	325	112·7	...	...	...	...	Coaled remainder of cwt.
6	4 15	...	249	17	146	323	110·5	...	112			
		1·83						106·5		84	·788	

TABLE II.

TEST.			PRESSURE, &c.		WORK.				CONSUMPTION OF FUEL.			REMARKS.
			Boiler.	Condenser.	Engine.	Brake.	Horse Power.		Welsh Coal.			
No.	Time of taking test.	Duration of test in decimal hours.	Pressure per square inch in lbs.	Vacuum in inches.	Revolutions per minute.	Pull in lbs. on Salter's balance.	H.P. developed on brake at each test.	K average H.P. on brake.	Total coal consumed in lbs.	W Coal consumed per hour in lbs.	$\frac{W}{K}$ Coal consumed per H.P. hour in lbs.	
	H. M.											
1	3 0	...	262	17	134	320	100·5					
2	3 15	...	250	17	140	319	104·7					
3	3 30	...	250	16·5	140	318	104·4					
4	3 45	...	250	17·5	142	319	106·2					
5	4 0	...	249	17	148	325	112·7					
6	4 15	...	249	17	146	323	110·5					
7	4 30	...	238	16·5	142	322	107·2					
8	4 45	...	242	17	146	322	110·2					
9	5 0	...	239	17	144	321·5	108·5					
10	5 15	...	225	17	136	320	102·0					
11	5 30	...	225	17·5	136	320	102·0					
12	5 45	...	225	17·5	136	320	102·0					
13	6 0	...	225	17·5	128	320	96·0					
14	6 15	...	225	17·5	132	320	99·0					
15	6 30	...	225	17·5	134	323	101·4					
16	6 45	...	225	17·5	136	323	103·0	...	...	...	...	Finished coal at 6 h. 50 m., and engine run down.
17	7 0	...	225	18	133	322·5	100·5					
18	7 15	...	220	18	110	292	75·5					
19	7 30	...	205	18	112	292	76·9					
20	7 45	...	200	17	148	292	101·6	...	392			
...	...	4·83	...	...	...	...	...	101·24	...	81·1	·801	

TABLE III.

TEST.			PRESSURE, &c.		WORK.				CONSUMPTION OF FUEL.			REMARKS.
			Boiler.	Condenser.	Engine.	Brake.	Horse-power.		Welsh coal.			
No.	Time of taking test.	Duration of test in decimal hours.	Pressure per square inch in lbs.	Vacuum in inches.	Revolutions per minute.	Pull in lbs. on Salter's balance.	H.P. developed on brake at each test.	K Average H.P. on brake.	Total coal consumed in lbs.	W Coal consumed per hour in lbs.	$\frac{W}{K}$ Coal consumed per H.P. hour in lbs.	
	H. M.											
...	7 50	...	...	...	...	...	...	...	...	...	...	56 lbs. were fired at 7.50, and the remainder at intervals.
1	8 0	...	200	15·5	132	274	85·2					
2	8 15	...	200	16	146	275	94·5					
3	8 30	...	200	16·5	148	274	95·5					
4	8 45	...	200	16	140	304	100·0	...	...	...	...	Engine running without fresh coal from 9 o'clock.
5	9 0	...	200	15	130	320	97·5					
6	9 15	...	160	15	126	246	73·3					
7	9 30	...	125	14·5	114	277	74·3		112			
		1·66						88·61		67·2	·758	



1. STEAM PRESSURE. 2. BRAKE HORSE-POWER. 3. REVOLUTIONS OF ENGINE.

The ordinates in the above table of curves are divided in such a manner that each interval represents 10, while each division of the abscissæ stands for periods of time, viz., hours and quarters.

* This point shows clearly where an improvement took place in running the engine, after it was discovered that the air spring had not been working satisfactorily and the fault was removed.

TABLE IV.—WHOLE TEST.

TESTS.			PRESSURE, &c.		WORK.				CONSUMPTION OF FUEL.			REMARKS.
			Boiler.	Condenser.	Engine.	Brake.	Horse-Power.		Welsh Coal.			
No.	Time of taking tests.	Duration of test in decimal hours.	Pressure on square inch in lbs.	Vacuum in inches.	Revolutions per minute.	Pull in lbs. on Salter's balance.	H.P. developed at each test.	K average H.P. on brake.	Total coal consumed in lbs.	W Coal consumed per hour in lbs.	$\frac{W}{K}$ Coal consumed per H.P. hour in lbs.	
	H. M.											
1	3 0	...	262	17	134	320	100·5	...	...	...	...	Coaled at 3 h. 2 m.
2	3 15	...	250	17	140	319	104·7					[doors.
3	3 30	...	250	16·5	140	318	104·4	...	...	...	...	Coaled at both furnace
4	3 45	...	250	17·5	142	319	106·2	...	...	...	...	Coaled right door.
5	4 0	...	249	17·0	148	325	112·7	...	...	...	...	Coaled at 4 h. 20 m.
6	4 15	...	249	17	146	323	110·5					
7	4 30	...	238	16·5	142	322	107·2	...	...	...	...	Coaled at 4 h. 40 m.
8	4 45	...	242	17	146	322	110·2	...	...	...	...	Coaled at 4 h. 50 m.
9	5 0	...	239	17	144	321·5	108·5	...	...	...	...	Coaled last of second cwt.
10	5 15	...	225	17	136	320	102·0	...	...	...	...	Coaled.
11	5 30	...	225	17·5	136	320	102·0	...	...	...	...	Coaled at 5 h. 40 m.
12	5 45	...	225	17·5	136	320	102·0					[cwt. at 6 h.
13	6 0	...	225	17·5	128	320	96·0	...	...	...	...	Coaled remainder of third
14	6 15	...	225	17·5	132	320	99·0	...	...	...	...	Coaled at 6 h. 18 m.
15	6 30	...	225	17·5	134	323	101·4	...	...	...	...	Coaled at 6 h. 50 m., all
16	6 45	...	225	17·5	136	323	103·0					available ashes used up
17	7 0	...	225	18	133	322·5	100·5					and engine allowed to run down.
18	7 15	...	220	18	110	292	75·5	...	...	...	...	Air pump not quite main-
19	7 30	...	205	18	112	292	76·9					taining air spring in last
20	7 45	...	200	17	148	292	101·6					pump.
21	8 0	...	200	15·5	132	274	85·2	...	...	...	...	Fired up at 7 h. 50 m. with
22	8 15	...	200	16	146	275	94·5					new half cwt. to get up power quickly.
23	8 30	...	200	16·5	148	274	95·5	...	...	...	...	The rest of 504 lbs. used as
24	8 45	...	200	16	140	304	100·0					required until 9 o'clock,
25	9 0	...	200	15	130	320	97·5					when engine again was
26	9 15	...	160	15	126	246	73·3					allowed to run down.
27	9 30	...	125	14·5	114	277	74·3	...	504			
...	...	6·5	...	...	...	...	...	98·0	...	77·54	·791	

commercial value of the invention, that is to say, the available or brake horse-power.

Continuous watch was kept to see that no more than the amount of coal weighed out was burnt.

Readings were taken every quarter of an hour, and notes made whenever coaling was necessary.

At one period of the run the engine did not appear to be doing its best, and on investigation it was found that the pumps supplying the air to the pump which returns the mixture of steam and water to the boiler, were not fulfilling their duty in a quite satisfactory manner and did not maintain the air spring—the most important detail in the Marchant engine—with sufficient air to make up for leakage and waste.

On this defect being remedied matters improved, but at the same time, there is no doubt the general efficiency was somewhat impaired, and we shall look for better results in the future than those we have tabulated.

The supply of cold water to the condenser during the above trial was barely sufficient. This has since been altered and a plentiful service has been put on ; several minor defects have also been attended to with beneficial effects, judging from a two hours run on Monday last, which showed enhanced efficiency.

The above figures corroborate the tests previously made and published in a circular issued by the syndicate. We understand that many licenses have been taken up for manufacturing under royalties, and that shortly a small engine of a horizontal type will be running.

We would recommend those of our readers who have not seen the Marchant engine to do so, as every facility is granted by the owners for its public inspection.

The patents are the property of the Marchant Engine Syndicate, Limited, 24, John Street, Bedford Row.

ELECTRIC LIGHT AND EXHIBITIONS.

HOWEVER the question of electric lighting may at present stand in regard to general public and private purposes, it is virtually certain that no national or international or even local exhibition could now be arranged without electric lighting figuring conspicuously. Consequently it is not surprising to find that the producers and engineers of this illuminant will have a busy time next year among the numerous international exhibitions to be opened in celebration of Her Majesty's Jubilee. At Manchester, Newcastle, Saltaire, and probably at Glasgow and Hull, in all of which towns there are to be exhibitions, the electric light will be the principal illuminant ; while in the first three cases at all events there will be sections for the display of the engines and other apparatus for producing the light—as well as the machinery required for electricity for other purposes. At Newcastle, an executive committee for arranging the electric lighting section has already been appointed, Prof. Garnett being chairman and Mr. W. Cross vice-chairman. A second committee will take charge of the electric lighting class of the hygiene division ; and at the same time there will be under the same division a committee upon gas lighting and manufacture, and "other modes of lighting." The new Agricultural Hall at Kensington ("Olympia" as it is to be called) will of course be illuminated by electricity, inside and out ; and at the Congress of the Sanitary Institution at York next week the electric light will be used in the same way, while the necessary appliances will be shown in the exhibition which opens with and lasts beyond the congress itself. Simultaneously with the exhibitions next year, but in no way connected with them, will be an international one at Barcelona, and there also the buildings will have the benefit of the electric light, and visitors will be able to study the process of generating and applying it by means of the exhibits in one of the sections.

THE BRITISH ASSOCIATION.

(Specially Reported for the "Electrical Review.")

LITHANODE.

By DESMOND G. FITZGERALD.

(Section A.—Mathematical and Physical Science.)

Wednesday, September 8th.

THE object of the present paper is to draw attention, as briefly as possible, to a substance for which it is claimed that it constitutes the negative element, *par excellence*, for voltaic batteries, primary or secondary, and also a perfect anode for the electrolytic separation of the most electro-negative elements, *e.g.*, chlorine.

It may be as well at once to specify the main desiderata in a negative voltaic element, and also the essential conditions in an anode applicable generally and commercially in electrolysis.

A negative voltaic element should be not only strongly electro-negative (inoxidisable) in itself, but also capable of retaining its electro-negative condition when constituting a cathode traversed by a (comparatively) strong current for a (comparatively) long period of time.

The electro-negative material of which it is constituted should not be associated with any relatively electro-positive substance, in contact with it and with the electrolyte ; or, in other words, local voltaic action should be impossible. It should not be liable to disintegration or corrosion.

From an economic point of view it is essential, in order to render practicable the use of the element on an extended scale, that the abstract cost of the energy developed by means of the voltaic combination of which a given negative element forms part should not exceed one halfpenny per horse-power hour. It is most desirable, and it is also quite within the limits of practic ability, that this cost should not exceed half this value. In other words, it is most desirable that we should be able to show in any given locality, that we can restore to a given battery, constructed with the given negative, the energy corresponding to an expenditure of 736 watts during one hour by means of the combustion of one farthing's worth of coal. From another economic point of view it is desirable in certain applications that the ratio of battery work to weight of negative element (inclusive of depolarising substances) necessary to develop this work should be relatively high. Lastly, an efficient negative voltaic element must possess a degree of conductivity such as will admit of a very low ratio between the quantity of energy converted into heat by the passage of electricity through its substance, and the quantity of energy converted into heat by the passage of electricity through the electrolyte under the best conditions obtainable.

Excepting the substance now presented to your notice, there is no negative voltaic element in which all these desiderata are fulfilled.

The essential conditions in an anode applicable generally for electrolytic decompositions on a large scale are that it must be chemically unattackable both by oxygen and by chlorine in the nascent state ; it must not disintegrate by the action of the gases evolved from its surface ; surfaces of any required area must be obtainable without any liability to augmented resistance and consequent sparking and heating at joints in the material ; it must possess sufficient hardness to resist abrasion by contact with ores, &c. ; and its cost must be small. The applications for an anode fulfilling all these requirements are practically unlimited ; but with the exception of the substance I now bring before you, there is no material possessed of all these desiderata.

This substance termed lithanode, which for some time past has been known to a few electricians in this country and in France, is peroxide of lead in a dense, coherent, and highly conductive form, obtained, without any admixture of inert cementing or agglutinating material, and free from any contact with lead or other oxidisable body, by a process of which the original and essential features are described in my patent specification of April 15th, 1885. But before adverting to the principle involved in its manufacture, it will be interesting to glance at the *raison d'être* of lithanode and to its position in the series of inventions by which the storage battery of the near future has gradually been evolved. Planté obtained peroxide of lead—almost identical in chemical composition with lithanode—in the form of very thin layers in contact with metallic lead.

The objections to Planté's negative were due to the difficulty of sensibly augmenting the thickness of the layer of peroxide initially obtained, and also to the local action between this layer of oxidant and the metallic lead beneath it. The former of these objections was overcome by Faure, whose inventions rendered it possible to obtain layers of active material of any required thickness. The objections to Faure's negative were threefold : first, the necessity for the use of parchment paper or felt to maintain the layer of active material in position ; secondly, the liability to defective contact between this layer and its supporting lead plate ; and, thirdly, the local action between the peroxide and the metal, limited, it is true, by the circumstance on which the preceding objection is based, but resulting, nevertheless, in a continuous waste of energy and in the ultimate destruction of the supporting plate. The first of these objections, and, to a great extent, the second also, have been obviated in the Faure-Sellon-Volckmar accumulators manufactured by the Electrical Power Storage Company ; but the third objection is still applicable to the nega-

tive element in this otherwise greatly-perfected form of secondary battery.

Obviously the next step in the process of development was to realise the condition I have referred to, under which local action is entirely precluded. This step almost necessarily involved a complete alteration in the form of the negative element, and a coherent plate of active material, independent of any surface support, afforded the most perfect solution of the problem, although in certain cases a support of non-conducting material might be useful. The question was, how to obtain a dense coherent plate of peroxide of lead without the use of any cementing or agglutinating substance of which the effect would be to augment fatally the resistance of the electrode? This question has received a practical solution only after many failures, some of which bore at first the appearance of success.

If we mix oxide of lead with water, and mould the plastic mass thus obtained into the form of a plate, this, as might be expected, will be very friable when dry; and, when immersed in a fluid, will resolve itself into the original pasty form. In order to obtain a coherent solid without the use of an inert cementing body, it is necessary to produce a molecular change in the plastic mixture, so as to cause it to "set." Such a molecular change may most readily be brought about by a partial chemical change occurring in the moulded mass, provided such change be not too rapidly effected. If, for instance, we blend a certain proportion of finely-divided metallic lead with the oxide of lead and water, the rearrangement of molecules due to the gradual oxidation of the lead in presence of air will have the effect of greatly increasing the cohesion of the mass so as to allow of its immersion in a fluid without disintegration. The resulting plate, when electrolytically peroxidised, will possess a considerable degree of cohesion and hardness constituting the product known to some electricians under the somewhat barbarous term of *petranode*. Better still—and this is the invention to which I would draw your attention—if we mix our oxide of lead with a solution of a salt which will gradually be decomposed by the oxide—as, for instance, ammonic sulphate, from which ammonia is evolved whilst a certain proportion of the lead oxide is converted into plumbic sulphate—we may obtain a dense and coherent mass which, when electrolytically converted into peroxide of lead, constitutes *lithanode*.

From what has been said, it will be seen that this substance is in chemical composition almost, if not quite, identical with the active material in the anodes of the various forms of secondary battery which have been proposed for use on a large scale. The difference is one of molecular constitution, allowing of the use of an anode wholly composed of peroxide of lead, and consequently entirely free from the liability to local action. Moreover, the anode in question—unlike those which may be constructed with chemically produced peroxide of lead—possesses in sufficient degree the quality of conductivity, and will withstand without deterioration and for an indefinite period the effects even of very rapid charge and discharge, when used in voltaic batteries, either primary or secondary. It offers a threefold advantage: first, it gives us a permanent element in lieu of one which contains the elements of its own destruction; secondly, it economises the energy elsewhere expended in local action; and, thirdly, it enables us to reduce the weight of the apparatus. The importance of this result does not need to be insisted upon in addressing electricians and electro-chemists. For the first time we have it now in our power to construct an anode which with absolute impunity will withstand the test of a perfect voltaic negative—the electrolytic evolution of chlorine.

I have to apologise for the very imperfect manner in which I have been able to bring this material to your notice. Important improvements in its manufacture are in course of development; and I am unable, therefore, at the present moment to give more than a somewhat abstract view of the latest step that has been made in perfecting the secondary battery, and also the means for carrying out various processes of electrolysis on a commercial scale.

Discussion.

Lord MACLAREN asked whether the process had yet been commercially applied, or whether it was still in the experimental stage.

Mr. FITZGERALD replied that it was still in the experimental stage, although thousands of comparatively large plates had been manufactured for experiments which were kept strictly secret, and it was only in the face of a great deal of opposition that he, the inventor, had been able to bring a few samples of the material to lay before the section.

ON THE PROOF BY CAVENDISH'S METHOD THAT ELECTRICAL ATTRACTION VARIES AS THE SQUARE OF THE DISTANCE.

By PROFESSOR POYNTING.

(Section A.—Mathematical and Physical Science.)

Thursday, September 2nd.

THE proof of the law of electrical action depending on the fact that there is no electrification within a charged conductor was first given by Cavendish. His proof was made more generally by Laplace, who has been followed by other writers, including Maxwell.

Maxwell and MacAlister have also verified the experimental fact, repeating an investigation by Cavendish only recently published in Maxwell's edition of his researches.

The proof may be analysed in the following way:—

Taking the case of a uniformly charged sphere, the action at a point within it may be considered as the resultant of the actions of the pairs of sections of the surface by all the elementary cones with the point as vertex. If, then, the resultant action is zero for all points and for all sizes of the sphere, it follows that the action of the pair of sections by each elementary cone is zero, and since the sections of the surfaces are directly as the square of their distances, the actions per unit area must be inversely as the squares of the distances if the two sections neutralise each other.*

There appear to be two objections to this proof:

1. It takes no account of the always existing opposite charge. When the sphere is, for instance, positively charged an equal and opposite negative charge is on the walls of the room, and the action of this should be considered. Probably this objection could be removed.

2. There is a solution still simpler than the inverse square law, viz., that no element of the surface has any action within the closed conductor. If we suppose that a conductor is a complete screen to electrical action, then whatever the law of the force exerted across an insulator there will be no action within the conductor.

In any *null* proof it is not sufficient merely to show that there is no action in the null arrangement, but it is also necessary to show that on distributing the null arrangement some action is manifested. Now, in the case here considered it is impossible to obtain any action within the conductor in any statical arrangement. It is only during changes of the system, *e.g.*, while charging or discharging that we can get a disturbance of the null arrangement. But here new phenomena come in, for we have currents and therefore electro-magnetic actions.

But even disregarding the different kind of action occurring, the only experiment which I know of on this point is that of Faraday with his electrified cube. While the most violent charges and discharges were taking place on the outside of the cube, so that the null arrangement was probably distributed, he found no action on his electroscopes within.

Possibly the actions were alternating and so rapid that no electroscope of ordinary construction would reveal them. But he himself went into the cube, and he would probably be sensitive to rapidly alternating electromotive forces. It appears to me then that we cannot accept this proof, and must fall back upon the more direct proof of Coulomb.

I do not know whether Maxwell was aware of this objection, but it is worthy of note that in the remarkable fragment published since his death on the "Elementary Treatise on Electricity," he returned to Coulomb's proof and was apparently building up the mathematical theory of electricity in a way quite different from that followed in his larger work.

Discussion.

Dr. MACALISTER, being called upon by the President, said he thought he should be making public for the first time the way in which an experiment upon this subject was conducted. Prof. Clerk-Maxwell in the last summer before his fatal illness asked him to make this experiment, the reason probably being that the professor had set a question in the Tripos a little before, bearing upon the subject, and he (Dr. MacAlister) was the only candidate who attempted to deal with it. The experiment was difficult at first from the small charges caused by friction of the silk fibres, and so on, but when the source of error had been removed the mean result of the experiments was that p was practically zero. Prof. Maxwell was perhaps prevented from publishing the result by his illness. When Dr. MacAlister suggested publication he remarked that if the result had proved that the law was wrong, it would certainly have been worth publishing. Dr. MacAlister said that the experiment proved that if the charge did act through the metal then the inverse square law held. He could not, however, see his way at present out of the difficulty raised by Prof. Poynting, though he thought a way might perhaps be found. The question was this. Two spherical conductors are arranged concentrically, the outer one being hollow, and surrounding the other. The outer one is charged and connected with the inner one. Supposing the law of force to be slightly different from the inverse square, say the inverse $(2 + p)$, the power of the distance where p is very small, calculate the charge on the inner sphere in terms of the radii of the spheres, the charge given to the outer sphere, and the quantity, p. Or given the radii and the original charge, and the charge on the inner sphere, then p can be found. The experimental arrangement consisted of an inner wood sphere covered with tin foil surrounded by an outer copper sphere, insulated from it, and with an air space between the two. In the outer sphere was a small door or lid, which could be pulled open by means of silk fibres. A wire projected from the door inwards, so that when the door was shut it touched the inner sphere and thus established electrical connection with the inner sphere. The outer sphere being charged when the door was shut, it was then opened, the outer sphere was discharged, and a wire connected to a quadrant electrometer was made to project through the opening and touch the inner sphere.

* A proof was given by the author in the memoirs of the Manchester Literary and Philosophical Society Session 1876-7, without the use of a functional equation.

If there were any charge on the inner sphere, then the electrometer would show it.

Prof. FITZGERALD asked Prof. Poynting whether the idea he had in his mind was that there was no force at all produced through the conductor, so that there was no electrical induction at all through the conductor, because he thought it was extremely improbable, unless the whole of Maxwell's theories were wrong, that there was not something of the nature of electrical induction through a conductor. There was no line to be drawn between conductors and non-conductors. Substances ranged from worse to better conductors, and even good conductors had the power of transmitting light to a certain extent; therefore there was the possibility that there was some electro-static induction through them. He should not have thought there was any of the property of matter passing electro-static induction as distinct from its conductivity, because otherwise it would be possible to get things which were not conductors, and yet were susceptible of electro-static induction. Now, there was nothing at all approximating to that. Faraday mentioned an experiment with a cube having a strong electrical charge on the outside of it. The outside of the cube being a wire gauze, and, secondly, his body acting as a short circuit across the inside of it, there would be an enormously greater resistance than the outside wire gauze would give alone, and he did not think Faraday expected to feel any results. If one thing were put on one side, where the spark was going, and the other on the other side, the same effect would be obtained. He (Prof. FitzGerald) would not have expected that Faraday would feel a shock any more than he would expect a person to experience a shock when discharging a Leyden jar through the discharging tongs, and even there there was a much greater quantity of electricity passing. He did not think there was any other evidence of a conductor being a subject of electro-static induction. The effect of all the phenomena was to explain that a property of matter was to facilitate the conduction of electricity. The fact that you could get a graduated series of things that became better and better conductors, all of which propagated light, until you got very fair conductors, showed that electro-static induction took place through the conductor.

Prof. POYNTING said his only difficulty with regard to what Prof. FitzGerald had said was that he entirely agreed with him. But he did not think it made any difference with regard to his objections to Cavendish's proof, that he thought there was no electrical induction in any *statical* experiment with metal. He agreed with Prof. FitzGerald that the current was in all probability essentially a *temporary* creation of induction in the metal, but this immediately decayed. He held that in the Cavendish experiment the outside world was entirely separated, electrically, from the inside world. There may have been a temporary induction whilst electrical currents were passing outside and inducing currents inside, and possibly there were lines of magnetic force straying through, but that was electro-magnetic, and not electro-static.

Prof. EVERETT, F.R.S., did not quite understand the objection Prof. Poynting had raised to Cavendish's proof, nor did he understand what the alternative offered was. He had stated his objection in some such words as these, that the reason why we find no force in the inside may be because the conductor completely screens the inside from the action of the electricity outside; not only screened as regards the resultant effect, which was just Cavendish's conclusion, but screened each individual portion of the electricity on the surface from acting upon the inside. That he took to be the alternative suggestion, that electricity on the small surface outside was completely screened from acting on the inside, and screened not by producing a charge on the inside, the direction of which counteracted it, but screened in some negative way, some way that prevented anything being done. He did not know of any electro-static screen due to the interposition of a conductor. They knew that if they interposed an insulated conducting plate between the charged body and the point where they wished to measure the effect, there was an effect. But how an interposed plate acted as a partial screen had not been completely explained.

The PRESIDENT, in thanking Prof. Poynting, said his communication went to the very root of all electrical theories.

A PORTABLE ELECTRIC LAMP.

By W. H. PREECE, F.R.S.

(Section G.—Mechanical Science.—Monday, September 6th.)

THE demand for a new safety lamp in mines has directed many minds to the application of electricity to this purpose. Some have proposed to use primary batteries; others utilise secondary batteries or accumulators. One of the most portable, compact, and convenient forms is that of Mr. Pitkin. It occupies a cubical space of 59 cubic inches for two cells, and 86¼ cubic inches for three cells, weighing 5 lbs. 8 ozs. and 7 lbs. 3 ozs. respectively. The three-cell battery gives a light equal to 25 candles immediately after removal from the charging source, and lasts for nine or ten hours. I have also used it for other purposes. It is a most convenient portable lamp for going into a wine cellar, or visiting our greenhouses, and it makes a very convenient reading lamp for railway travelling. I carry such a battery in my dressing bag, and by means of a flexible cord carrying two copper conductors, I suspend by a hook to my waistcoat front a small candle-power Edison-Swan lamp that concentrates upon my book or my paper all the light I want. The lamp is fixed in the focus of a reflector, whose surface is enamelled dead white instead of being bright polished. The light is thus much more equably and uniformly distributed. It is, moreover, soft, absolutely steady, and free from smell or annoyance to my fellow passengers. It is lighted instantly without any match, and it can be rapidly replaced by a small coil of fine platinum wire which, being raised to incandescence, enables me to light my cigarette.

IMPROVEMENTS IN ELECTRIC SAFETY LAMPS.

By J. WILSON SWAN, M.A.

(Section G.—Mechanical Section.—Monday September 6th.)

I SHOWED an electric safety lamp in this section last year. I have now improved the lamp in various ways, and I propose to describe and exhibit the improvements.

The objects I had in view in altering the original design were:—

1. To reduce the weight as much as possible, consistently with the giving of sufficient light.
2. To simplify the construction, with a view to minimising the cost of manufacture, and the cost of keeping in order.
3. To make the lamp better able to resist a blow.
4. To seal in the liquid, so that the lamp could be held in any position.
5. To add a fire-damp indicator.

The lamps on the table embody these improvements, and are here for the inspection of members.

The details of construction and the record of experiments are given in the diagram.

With regard to the first point—namely, the size and weight of the apparatus—that, of course, depends in a great degree on the amount and duration of the light. Guided by the fact that the best of the oil safety lamps scarcely gives the light of one standard candle, and that most of those in common use give only a quarter or half a candle, I have assumed that an average light of one candle, over 12 hours for datal men, and 1¼ candle over 9 hours for hewers is sufficient, and I have fixed the size of the battery in the new lamps on this assumption. No alteration of the design is necessary when more or less light than this is required, but merely an increase or decrease of the size and weight of the battery contained within the lamp body.

In this respect the electric safety lamp has a marked advantage over all safety lamps of the ordinary kind, which depend on the combustion of oil; *they* cannot be made to give a much larger light without radical alteration, if at all. If the electric safety lamp is required to give 5 or even 10 candle light, it is only necessary to proportionally increase the size and weight of the battery. Safety is not in the slightest degree impaired.

There is nothing easier than to be deceived as to the amount of light that can be obtained from a certain size and kind of battery applied to an incandescent lamp. If the lamp is constructed so as to allow such a large current to pass through the carbon filament as will heat it to the enormously high temperature at which disintegration rapidly takes place, ten times as much light is produced as when, by the use of a different lamp, the current is diminished, and the temperature of the filament thereby lowered to a degree which will prolong the life of the lamp to an economical point.

In the case of a miner's safety lamp, it is very desirable to get as much light as possible from a given weight of battery, and hence it is allowable to subject the lamp filament to what may be termed a rather high pressure, but not such a high pressure as will prevent the lamp from lasting about 700 hours. Subject to this condition I find I can obtain an average light of one standard candle during 12 hours, and 1¼ candle during 9 hours, from a battery, which, with all the appurtenances of the lamp attached to it, weighs altogether 6¼ lbs. The same battery, with a different lamp filament, will, of course, give either more light for a shorter time, or less light for a longer time than that I have mentioned.

The battery cells are slightly different in construction from those in last year's lamp. They consist, as before, of a central solid cylinder of peroxide of lead, with a conducting core of lead wire, fixed concentrically, by means of guide rings of India-rubber, within a tube of lead, the internal surface of which is in the spongy state. The annular space between the peroxide of lead cylinder and the lead tube is filled with dilute sulphuric acid. Four such elements are fitted into four ebonite lined holes in a block of wood saturated with paraffin. The lead wire connections between cell and cell are covered with India-rubber, and embedded in channels in the wood, and covered with Chatterton's compound. Over the buried connecting wires is fixed a veneer of ebonite, which further protects them, and also forms a level seat for the cushion of India-rubber, which, when pressed down by the cover-disc makes the cells liquid tight, so that the whole block may be laid on its side, or inverted, without leakage.

In the form of lamp I showed last year, the cover of the case which contained the battery, had to be screwed off to get at the battery terminals, for the purpose of putting them in connection with the charging circuit. In the new design, the removal of the cover is avoided by bringing down the battery terminals to the bottom. Access is given to these through two small holes, within which fit two pins connected with the positive and negative charging wires. Charging is effected by simply placing the lamp on a bench fitted with charging pins, in connection with wires from a dynamo, so that the charging pins enter the two holes at the bottom of the lamp case. The lamps remain on the

dynamo circuit, receiving their charge during the time the men who have used the lamps are resting, and they become fully charged by the time these men return to work.

It is a point in favour of this kind of lamp that the operation of renewing the charge is effected with little trouble and cost—far less than is involved in replenishing and cleaning ordinary safety lamps. For example: one horse-power is sufficient to charge 100 lamps at a time; that item of cost will, therefore, not exceed a farthing a lamp per week.

The total cost will not exceed 5d. per week where several hundred lamps are in constant use. That amount will, I estimate, cover the total weekly cost per lamp, including renewal of lamp-bulbs, the cost of fuel, wages for keeping the lamp charged and in repair, and interest at 10 per cent. on the capital outlay for the whole plant, including the lamps themselves.

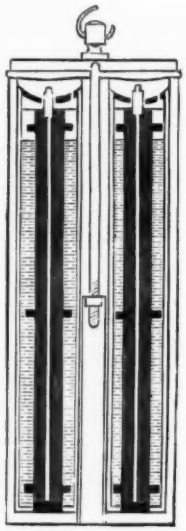


FIG. 1.

In one of the modifications of the lamp the light is fixed upon the top of the case, with a view to the illumination of the roof and sides of the mine.

This form of lamp is intended for the use of overmen while travelling in the workings.

The bulls-eye form, with the light on one side, is intended for the use of the hewer. While the hewer is at work the lamp will be hung up on a hook as usual.

Where low workings have to be traversed the lamps can be fastened to the breast of the miner by a strap across the shoulder.

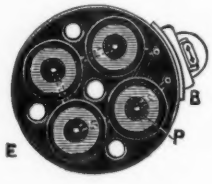


FIG. 2.

The only other point requiring explanation is the fire-damp indicator. The want in the lamp I showed last year, of the means of showing the presence of fire-damp, was urged as an objection to it. I have met the objection by adding an indicator. This will not be required on every lamp, but only on lamps used by overmen. I have made the indicator in three forms; two of these act on the same principle as Liveing's fire-damp indicator. A spiral coil of thin platinum wire is arranged so that it can be heated to a low red heat by switching through it the current generated by the lamp battery. If this takes place in an atmosphere in which fire-damp is present, the wire becomes hotter than when heated in pure atmospheric air, because combustion of the fire-damp with the oxygen of the air, brought about by the electrically heated wire, produces additional heat, and, consequently, increases the temperature of the wire, so that it is sensibly brighter when heated in air containing fire-damp than when heated in air in which there is no fire-damp.

In one form of the indicator I have followed Mr. Liveing's idea of having a comparison wire, shut up, air-tight, in a glass tube containing pure air. In another I have deviated from Liveing's construction in two ways, namely, by having only one wire (the test wire), and instead of this being in a wire gauze cage, always exposed to the atmosphere in which the lamp is placed, it is in a tube which, when the current is turned on to heat the wire, is completely closed. It is not easily conceivable, even if the test were made in an atmosphere of air and fire-damp of maximum explosiveness, that flame would pass the four-fold lining of fine copper wire gauze of the Liveing indicator; still it is, perhaps, more consistent with the absolute safety of the lamp itself, to make the test in a closed vessel. With the double wire arrangement, when fire-damp is present in the air, even in so small a proportion as half a per cent., the *exposed* wire glows with perceptibly greater brightness than the *enclosed* comparison wire. With the single wire arrangement, under the same atmospheric conditions, the wire would glow for an instant with extra brightness, and then, after the small quantity of enclosed fire-damp is consumed, would die down to normal redness.

The third form of indicator acts upon a different principle. In it there is a platinum wire within a small tube, and the means of turning on the current from the lamp battery to heat the wire as before; but here the hot wire is employed only to effect the combustion of any fire-damp that may be present, with a view to the production of a partial vacuum resulting from the condensation of the watery vapour of the burnt gases. The degree of vacuum or shrinkage is shown by the rise of liquid in an adjacent gauge tube, and from this the exact percentage of fire-damp present in the air may be ascertained. This form of test is also, and necessarily, made in a closed vessel. The hot wire is completely cut off from contact with the outer air.

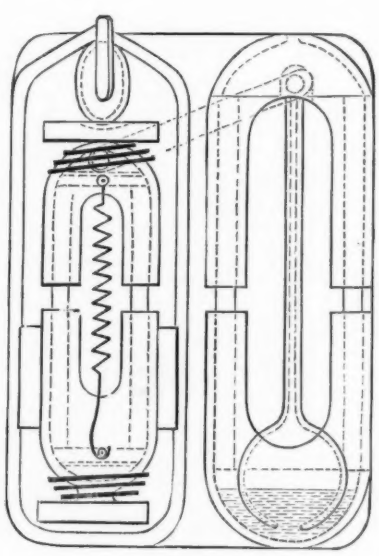


FIG. 3.

I think it will appear to the section that I have produced a miner's lamp having the advantage of absolute safety, and which is, at once, more efficient and more economical than any other miner's lamp yet constructed.

Perhaps I may be allowed to supplement what I have read by saying that the characteristic feature of the last lamp is the adaptation of a small incandescent lamp to a portable generator of electricity. The idea of such a combination was naturally in the mind of everybody immediately on the invention of the incandescent lamp, but it required that the manufacture of the incandescent lamp should be very greatly developed before we could possess the exact kind of lamp suited to the very small quantity of electricity which could be conveniently conveyed in a portable secondary battery. It required also that the secondary battery should be modified in its details so as to be at once a thing which would not be costly in production nor liable to get out of order, and it is in the meeting of these requirements, the carrying out of these details in an efficient way that I have been working. The idea of the incandescent lamp joined with an accumulator is an idea that would occur to anybody, but the making of an incandescent lamp suited to this purpose and the construction of an accumulator adapted to the use of rough workmen, not costing much to charge or keep in repair, are matters requiring very considerable thought and experiment.

DISCUSSION.

The PRESIDENT asked what would occur should the glass of the lamp become broken by accident.

Mr. SWAN said he had not had an accident of that kind, and he could not very easily conceive such a case arising. The protecting glass was exceedingly thick, and certainly a lump of coal, however large, falling upon it would not break it; the coal might break, but not the glass. By striking it with a hammer it might possibly be broken. Then what would happen would be that the small lamp, which was held between two springs would be knocked out of its place, and the circuit would be broken.

Prof. FORBES said he had been very much interested in the paper of Mr. Swan, because he had had occasion for a great many years, in conjunction with others, to work in the direction of promoting safety of working in coal mines. The first thing which would, of course, occur to every one in connection with these lamps was, what would happen if the lamp broke? The question had already been asked, and Mr. Swan had answered it; but he had not specifically told them whether or not if a lamp were broken in air containing an explosive mixture an explosion would take place. That might perhaps be beside the question, because Mr. Swan would probably say that such a thing would never happen. Still it would be satisfactory to have the question answered. The part of the paper which most especially interested him (Prof. Forbes) was that in connection with the detection of the presence of fire damp and the measurement of it. The miner's objection to an electric lamp was exactly what Mr. Swan had said, that it did not possess the power of indicating the presence of fire damp. An ordinary miner's lamp when taken into a coal mine where there was more than 1 per cent. of fire damp showed its presence at once by the blue tinge surrounding the flame, which enabled the miner to approximately detect what the quantity of the fire damp was. This ordinary means was the only apparatus used at present for determining whether there was fire damp in a mine or not. A great many years ago it was urged upon him by friends who had coal mines under their charge, that it was very important that some independent and more scientific method of detecting the presence of fire damp in mines should be introduced. A device occurred to him which seemed to be very promising, and that was to determine the density of the gas by means of the velocity of propagation of sound through it, or by means of the size of a resonator containing the air of the mine which would respond to a tuning fork of a definite pitch. He extended that system and made a practical instrument which was still in use in two collieries in Lancashire. It had been discarded, however, by most mines, because they preferred their old safety lamps. Last year Mr. Blakeley, who had made numerous experiments on the velocity of sound, asked to be associated with him in the improvement of his sound method, and together they made the instrument practically perfect. But the same objection still applied to it, and he did not think a great deal would be heard of the apparatus, although it was very perfect. Mr. Liveing had introduced a system which Mr. Swan had adopted in some of the indicators which he had shown, by which the heating of two wires by means of the passage of an electric current through them was employed, one wire being in pure air and the other in the air of the mine. If the air in the mine contained a hydro-carbon gas (fire damp) extra brilliancy was observable in the exposed wire. The indicator was very sensitive. Mr. Liveing had in it a photometrical arrangement to enable him to compare with accuracy the intensity of the brightness of the two wires. By that means he was enabled to measure distinctly something like one-half per cent. of fire damp. In the arrangement as Mr. Swan had it the percentage required to be greater in order to make its presence evident. He fancied the arrangement in which there was only one wire exposed to the fire damp and none for comparison was only sensible to 1½ or 2 per cent. of fire damp, but he would like to hear Mr. Swan's opinion as to the sensibility of the single wire. The method of the comparative wires seemed to promise to be very accurate indeed. He was reminded that a system of that kind was in use some years ago in some of the Belgian mines. It was, he believed, the invention of M. Somzee, and was exhibited in the Paris Exhibition of 1881. It was the most remarkable indicator he had ever seen. It was founded upon the same principle of consuming the fire damp and measuring by the rise of the mercury in the tube the quantity of fire damp which had been present. That apparatus was placed at the bottom of the mine and periodically it took into its reservoir a supply of the air of the mine, then analysed it by this method, the ordinary and most scientific method employed in the chemical laboratory, and then measured automatically the quantity of rise in the mercury and consequently the percentage of fire damp in the mine. Having performed the whole function by itself it telegraphed the result to the top of the pit and prepared itself to repeat the operation a quarter of an hour later. In conclusion, Prof. Forbes heartily congratulated Mr. Swan on the advance he had made, and also on the fact of his having suited his lamp to the taste of the miners, which was very necessary, for miners were most conservative people and objected to very great departures.

Mr. SOPWITH asked whether the lamps could be held in any position. It was important to know whether or not they could be used for examining the roof of a mine, as well as for other general purposes.

Mr. SWAN stated that the latest forms of the lamp might be carried in any position, and, as a matter of fact, one of the lamps which he produced had been carried considerable distances in a horizontal position.

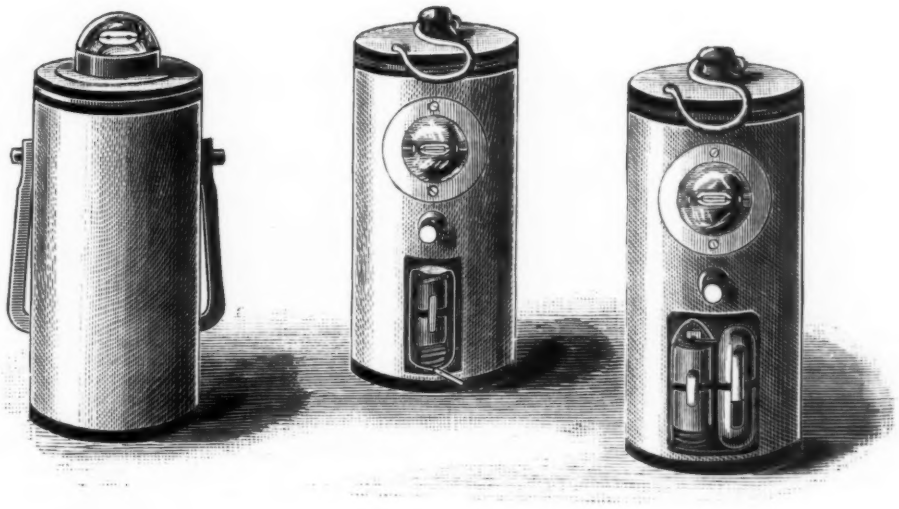


FIG. 4.

Mr. STURGE referred to the prize which had been offered by Mr. Ellis Lever for a safety lamp fulfilling certain conditions, and enquired whether the requirements were to be found in Mr. Swan's lamp.

Mr. SWAN said he had explained after reading his paper that the making of a really useful lamp depended upon the minute details in the construction of the lamp and upon the construction of the battery, and at the time when the competition for Mr. Lever's prize closed, perfection in the construction of the lamp was not a thing which could be easily obtained, and the battery had not been put into such a form as to allow the two combined to be sent in for the competition. But he had very little hesitation in saying that his present lamp did fulfil all the conditions required.

Prof. SILVANUS THOMPSON said he was one of the adjudicators appointed to award the prize in the competition which had been mentioned. The conditions were that the lamp should be self-contained, portable, giving a light at least as good as any safety lamp of the present day, and continuing to give that light for a number of hours. The conditions were not laid down by the adjudicators, but by the Miners' Association, which was represented by Mr. Burt at the adjudication. Prof. Grylls Adams, Sir Frederick Abel, and himself (Prof. Thompson), were the other adjudicators. They tested about 80 kinds of lamps, and even that number did not represent all that were sent in. Several were rejected at sight because they obviously did not fulfil some of

the conditions. One weighed a hundredweight, another shot out a ray of light in a straight line, and others possessed other defects. Amongst those thus rejected at sight was the lamp sent in by Mr. Swan, which had no battery to light it up with, and was not to be compared with the lamp just shown. Mr. Ellis Lever was dreadfully disappointed that his offer of £500 did not induce more than three competitors to send in electric safety lamps. All these three failed to fulfil the conditions, and were neither portable nor safe. The present lamp was entirely a different kind of thing. It was a lamp which a miner could carry in his teeth, strapped to his back, or in any other convenient way, and it would last for twelve hours. He did not think he was revealing a secret in stating that Mr. Swan's was not the only electric safety lamp which was coming into operation.

Prof. SMITH said last year he expressed the hope at Aberdeen that Mr. Swan would be able to add a fire damp indicator to his invention, and he was glad to see that that hope had been realised. Another great advance was that the weight of the lamp and battery had been reduced from 6¾ lbs to 5¼ lbs. A point which he would like elucidated was as to whether the spark which must occur at the point of disconnection in the event of the lamp being smashed would be likely to cause an explosion.

Mr. DESMOND FITZGERALD said he would like to point out that all secondary batteries were susceptible of great improvement by the use of what was practically a new invention for the negative element of the cell. In the diagram on the wall the red lines represented peroxide of lead, the most highly electro-negative substance, perhaps, with which chemists were acquainted, and the blue lines represented lead, which was an extremely electro-positive body. These two substances were in contact with each other and also with the electrolyte in the cell. The electricity passed from the lead to the fluid, from the fluid to the peroxide, and through the peroxide back again to the lead. The result was extremely detrimental to the working of all these batteries, as was generally understood. It was detrimental, in the first place, because there was a continual loss of energy in consequence of local action; and in the second place, the element as represented would be gradually destroyed. The great objection in this case, however, was the addition to the weight of the apparatus consequent upon the introduction of this lead which was so detrimental. The question had long been how to dispense with this lead. He ventured to hope that this question was completely answered by the introduction of a material which he termed lithanode, which was a peroxide of lead of high conductivity, and which was, in fact, comparable in its conductivity with carbon. Mr. Swan, whom he congratulated upon the success of his efforts to mitigate the awful sacrifice of human life consequent upon the obtaining of coal, would find that his battery could be very greatly reduced in weight by the use of lithanode as an element.

Mr. SWAN said he would answer in two or three words the remarks which Mr. FitzGerald had made. If Mr. FitzGerald had discovered any means of reducing the weight of the battery, his discoveries would be very welcome indeed. He had called attention particularly to the unnecessary weight involved in the combination of metallic lead and the oxide of lead in the ordinary construction of anodes in secondary batteries. No doubt there was a great deal of unnecessary lead used, and in the construction of his battery he had paid special regard to that point, both with the view of diminishing the weight, for which purpose he had used as little metallic lead as he possibly could, making the core like the wick of a candle, and also with the view of avoiding local action between the metallic lead and the peroxide of lead. He thought he had succeeded in his battery in reducing that local action to the very smallest possible limits, and the core of the anode, being placed in the centre, was removed very considerably out of the sphere of electrolytic action.

The PRESIDENT said they could scarcely realise the importance of the paper which Mr. Swan had read. They most of them knew, as a matter of historical interest, the great sensation produced when Davey brought out his first safety lamp. Although that lamp was a great improvement on previously existing forms, yet it was very imperfect. The poor miner had been compelled to work with that lamp for a number of years, and therefore they could not attach too much importance to the invention Mr. Swan had brought before them. In the first place he had introduced his incandescent lamp, and then had followed it up with the miner's lamp, and now there was every prospect that thousands of lives might be saved by the use of a very perfect instrument, and that perfect instrument was due to Mr. Swan. Whoever might follow up the question, Mr. Swan was the man who had introduced it, and he hoped they would join with him in according that gentlemen a hearty vote of thanks for his valuable communication.

REPORT OF THE COMMITTEE ON STANDARDS OF LIGHT.

(Section A.—Mathematical and Physical Science.)

Friday, September 3rd.

THE committee on standards of light met repeatedly during last winter. It had been proposed in last year's report to carry on experiments on electrical standards in the hope of arriving at an absolute standard of light. One of the first steps was to discover a means of reproducing a definite temperature, and certain experiments were proposed for this purpose. At one of the first meetings of the committee Captain Abney announced that he had already found a means of doing this in a different manner to that proposed in the committee's report, and depending only upon the change of resistance of the carbon filament with temperature. Under these circumstances the committee left this part of the experimental investigation to be reported upon by Captain Abney. His further researches have, however, led him to believe that the law which he had announced to the committee does not hold with all qualities of carbon filament. He has, however, been engaged upon further experimental researches which are almost ready for publication, and which have an important bearing upon the labours of the committee. In last year's report attention was drawn to the value of the pentane standard of Mr. Vernon Harcourt as a practical reproducible standard, and Mr. Rawson has been since then engaged in a further examination of this standard. Sir James Douglass has also made some experiments which are not quite completed, but have gone so far as to give great promise. Some account of these experiments in this report had been expected by the committee, but the absence of Sir James Douglass on official business has interfered with this. At one of the first meetings of the committee the secretary showed what he had done in the way of improving thermopiles, such as it was hoped would be of use in the investigations recommended in last year's report, and he was instructed by the committee to proceed with the construction of the instrument, which has been completed and is placed before the section, and described in a separate paper. The committee respectfully request to be reappointed, with a grant of £25.

ON A THERMOPILE AND GALVANOMETER COMBINED.

By Prof. GEORGE FORBES.

(Section A.—Mathematical and Physical Section)

Friday, September 3rd.

IT is my duty to bring before the section some account of an apparatus, a name for which I have not succeeded in fixing upon, but which I have spoken of as a combined thermopile and galvanometer, and that represents accurately what the instrument really is. A thermo-galvanometer may perhaps be a term suitable for the instrument, the object of which is to measure the radiation of heat in the manner which has been accomplished by the ordinary thermopile. The special instrument was designed more particularly for use in spectroscopic work, that is to say, to replace what has been generally known as the line thermopile, a thermopile which measures the intensity of light forming a linear image. Some account of the first forms of this instrument was given to the Royal Society last spring; since then, the instrument has been modified with the intention of making it more sensitive. The first apparatus which was constructed was extremely simple, consisting of a very short tube, made of two different metals, one half of the circular section being of bismuth and the other half of it of antimony. The two edges were filed down, so as to be very thin, and covered with a carbon surface, which absorbed radiation freely. The difference of the intensity of radiation between one junction and the other determined the direction of the electric current which circulated round the composite tube. This circuit naturally had an extremely low electrical resistance, and the compass or magnetic needle, like those employed in Sir William Thomson's galvanometers, was inserted in the tube and acted directly upon the low resistance circuit carrying the electric current. It was hoped that by thus lowering the resistance enormously, we should get an increased effect, and the result of experiment seems to support the theoretical conclusion. In the ordinary thermopiles we have a number of junctions, a number of pieces of antimony and bismuth joined together in series, and consequently they offer a much larger resistance than the composite tube, of which I have spoken. Moreover, they have the resistance of a galvanometer in the circuit, and in the communication to the Royal Society it was pointed out that one would expect *à priori* that the combination of a galvanometer and a thermopile would be about equal in efficiency to this combination if the galvanometer were made specially of a proper resistance and construction for the thermopile, a thing which is seldom attained in actual practice. The most complete form of instrument which I showed to the Royal Society consisted of a wedge of antimony and bismuth, combined. This is not an exact representation of the wedge, but it is near enough to it to show you the type. You see this is a wedge with a hole passing through close to the narrowest surface. In that hole a magnetised needle and its suspended mirror were placed. The upper part of the wedge consisted of antimony and the lower half of bismuth, and the heat striking the junction of these two determined the electric current which influenced the needle. That apparatus was found to be very sensitive indeed, and is probably as sensitive as any arrangement could be for use as a line thermopile. There was one very good point about it, it was very dead beat in its action. This large mass of metal with its low resistance acted as a damper upon the motions of the needle, rendering it exceedingly stable, and causing it to come to rest very rapidly. That was assisted, of course, by my employing in that instrument one of Mr. White of Glasgow's light mirrors, which are used in Thomson's galvanometer. I cannot conceive anybody using any other mirrors, although in England there seems to be a delight in those heavier mirrors supplied by London makers. Since then I have modified the instrument to make it more sensitive by making it astatic (fig. 2). Instead of having one set of magnets in the inside circuit only, I have another set outside on the same suspension. The instrument is thus rendered very much more sensitive, but it is not so dead beat. This wedge is enclosed in a brass covering,

and it has a cone to reflect the heat on to the surface of these two metals, and it also has a controlling magnet like the ordinary Thomson galvanometers. (See fig. 1.) In the present instrument I have put the magnet down as low as possible, to give it very great directive influence, because in this room there is so much tremor that it is difficult to see the action of the apparatus. The heat of my hand placed by the side of the instrument is sufficient to move the spot over a considerable range. This apparatus was made by Messrs. Nalder, and it strikes me as being extremely beautifully made; it is very much more delicate than the apparatus I showed originally.

Prof. FITZGERALD said he should like to know what Prof. Forbes thought as to the relative delicacy of thermopiles and bolometers. Prof. Langley had given an enormous preference to the bolometer as a delicate apparatus for measuring current. Prof. Forbes said he thought his instrument was as delicate as any other; did he include the bolometer?

Prof. FORBES said he agreed with Prof. Langley. He did not think there was the slightest doubt that the bolometer was very much more accurate than any thermo-pile arrangement. It was simply in comparison with thermopiles that he considered his instrument the most sensitive.

FIG. 1.

Lord ROSSE said the thought suggested by Prof. Fitzgerald, as to the relative merits of the bolometer and the thermopile, was worth more fully going into. He had had his attention drawn to the subject of the thermopile, and he had it in contemplation to try to ascertain really what its merits were. It seemed to him, looking over Prof. Langley's paper on the use of the bolometer and his experiments with it, that the advantages attributed to the bolometer were rather exaggerated. Prof. Langley did not draw sufficient attention to the fact that he took immense pains to make his galvanometers. He made the needle very much lighter upon the same principle that Prof. Forbes was very anxious to make it lighter, and he made it particularly dead-beat by a very simple and ingenious contrivance, using dragon flies' wings, and thus getting a very stiff and light damper. He (Lord Rosse) tried the same thing himself on a galvanometer; he stuck two dragon flies' wings on the back of the reflector with a small piece of wax; he then stuck two more wings at the ends of the others, and found that the galvanometer was driven to the end, stopped, returned very fast to zero, and he found that that zero was not perhaps more than 20 degrees. It was extraordinary how it was brought to rest after two or three oscillations. Prof. Forbes used a modified form of thermopile, but the ordinary thermopile had a number of advantages. It struck him that probably the E.M.F. was proportional to the elevation of the temperature; and if all the heat were sent into one solder ten times the temperature would be obtained for the same E.M.F. By this arrangement the resistance of the thermopile was very much reduced at once. He thought that subject wanted fuller consideraton. The plan by which he collected all the heat into one solder was by fixing one solder to the other by a thin sheet copper coil, and he believed that very rapidly carried all the heat of the disk on to the central solder. As regards the combination which Prof. Forbes had shown, it depended upon circumstances whether the arrangement would be a successful one or not. He himself used a thermopile placed in the focus of his reflector, and employed very large wires. For his purpose it was much more convenient to read the galvanometer in the observatory, and to have it more generally used by moving the telescope.

Lord RAYLEIGH said he would like to say one word on the point Professor Fitzgerald raised respecting the comparison between the bolometer and the thermopile. He also was under the impression that a great part of the improved results Professor Langley obtained was due more to the galvanometer and the other parts of his arrangements than to the substitution of the bolometer for the thermopile, but he would not go the length of saying that the thermopile was as good as the bolometer as a general proposition. Taking the case in which interest was probably greatest, where a linear element was wanted to investigate the spectrum with, in the nature of the case, even where the apparatus was capable of taking in a considerable area or section, the ground of the spectrum would prevent it being done. In the spectrum a practically homogeneous light was dealt with, and a comparison might be made between what E.M.F. would result from the change of fine wire and the E.M.F. which would be generated by induction at the same temperature of a single thermal element by putting two quite fine wires in such a manner that the junction came into the field of action. The comparison could not be made in any absolute way, because theoretically the sensitiveness of the bolometer might be increased without limit

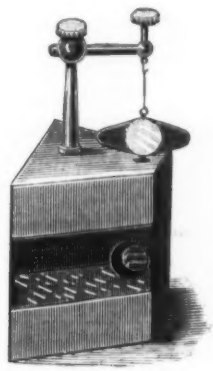


FIG. 2.

if the limits of the current passing through it could be indefinitely increased. Professor Langley did not give any sufficiently definite data to enable the limit of the current that passed to be fixed. In the thermopile the E.M.F. was proportional to the increase of current absolutely; in the bolometer it was proportional to the varying of the platinum or whatever it might be, and proportional to the magnitude of the current passing. But upon the data which Professor Langley gave it did not appear to him that much more E.M.F. was got out of the element forming the bolometer than you might have obtained out of a German silver and iron cone formed of two correspondingly thin wires put together. He had tried Lord Rosse's plan of using a large disc, and he had also tried a plan introduced by Lord Rosse of using a comparatively small disc, and he found that as good, or even a better result, was obtained in that way.

Lord ROSSE: I should like to add that Professor Langley contrasts his experiments with mine, but I think he overlooks the fact that although I had a much larger mirror to work with, I worked out in the open air and under various conditions of the atmosphere, whereas he worked in his observatory and was completely sheltered from draughts. That was such an important difference that the two sets of radiation experiments could hardly be compared.

A NEW FORM OF STANDARD SINE GALVANOMETER.

By J. T. BOTTOMLEY.

(Section A.—Mathematical and Physical Science.)

Tuesday, September 7th.

MR. GRAY proposes to use a coil of uniform wire laid into the thread of a screw cut with all possible accuracy on the surface of a cylinder. The absolute force at the centre of such a coil is calculated by a well-known formula. In the centre of the tube is hung a short magnetic needle with mirror attached. A short scale or mark at one end of the tube is received by means of a telescope at the other end of the tube, and the whole tube is turned round on a central transverse axis till maximum deflection of the magnet is obtained and the instrument is used as a sine galvanometer.

A MAGNETIC EXPERIMENT.

By W. H. PREECE, F.R.S.

(Section A.—Mathematical and Physical Science.)

Tuesday, September 7th.

MY daughter having finished a piece of needlework, roughly smoothed it down on her lap, and in doing so drove a needle into the palm of her right hand, breaking it into several pieces. All these pieces were extracted but one, and this could not be found by probing. It remained in her hand for a fortnight, causing much pain and inconvenience. An examination by Prof. Hughes with his induction balance, though giving faint indications of its presence, failed to localise it. I tried several forms of this apparatus, but failed. I strongly magnetised a very fine needle and suspended it to a light arm by a small paper stirrup and a single cocoon fibre. The damaged hand strongly deflected it, and by moving the hand about the needle invariably pointed to one position which was marked with a spot of ink. A free and deep incision was made in this spot, and the piece of needle, 4 mm. long, was found and extracted. The needle went through the opponens digiti minimi muscle, and was found deeply embedded under the deep palmæ fascia. The operation was performed by Doctors Pocklington and Page of Wimbledon.

Prof. G. FORBES said he should like to draw attention to the fact that Professor Tait performed a precisely similar experiment several years ago.

THE BLACKPOOL ELECTRIC TRAMWAY.

By M. HOLROYD SMITH.

(Section G.—Mechanical Science.—Saturday, September 4th.)

(ABSTRACT.)

General Conditions.—The general conditions are three :—Firstly, safety to the public ; secondly, efficiency ; and thirdly, economy.

With some reservations, the first condition may be accomplished by the employment of secondary batteries, which are destined to play an important part in the progressive development of electricity for tractive purposes ; but it must be admitted they occupy only a secondary place, when it is shown that electricity can be used direct, and can then fulfil not only the first condition, but the other two also.

The employment of the rails as lead and return conductors is out of the question ; for in large installations it must fail in regard to all three conditions. Side fence rails or overhead conductors, though fulfilling the conditions of efficiency and economy, are inadmissible for street purposes. There seems, therefore, but one course, and that is to place the electric conductors underground. This position involves many difficulties, some on first consideration apparently insurmountable.

Before the construction of the Blackpool electric tramway, many progressive experiments were made ; they have already been described and published elsewhere, and therefore it will not be necessary to give a detailed account of them here ; a brief reference to two will probably be sufficient.

The first full-gauge line was laid in a field near Manchester, and was 110 yards long. Here the conductor consisted of two half tubes, held in insulating supports ; and the collector was composed of two spirally fluted rollers, so held that they expanded and constantly pressed against the inside of the two half tubes, and maintained good contact with them, and by revolving cleared away any accidental obstruction that might be within the hollow open tubes. This action was all that could be desired ; but the objection to the method was that, in attempting to clear the channel, mud and dirt were liable to be piled against the iron chair and conductor, thereby spoiling the insulation ; and when once so piled, cleansing was a difficult and expensive process.

Requirements.—The conditions presenting themselves for solution are numerous, and may be classed as follows, according as they pertain to the conductors, to the motor, or to other general matters :—

Class A.—Conditions pertaining to the Conductors.

1. Protected electric conductors, so arranged that constant contact can be made and maintained, and yet not liable to damage.
2. Good and reliable insulation, free from fouling, and renewable in case of failure.
3. Facility for inspecting the whole length of the channel if necessary.
4. Ready means of regularly cleansing the channel, removing the ordinary street dirt, or any unusual accumulation.
5. Provision for working points and crossings for pass-byes and branches, without short-circuiting or failing to make contact.

Class B.—Conditions pertaining to the Collector.

6. Provision for making and maintaining contact between the motor on the car and the conductors within the channel.
7. Avoidance of damage, either electrical or mechanical, should the collector become blocked.
8. A construction of collector that will preserve its insulation and take the points of the turn-outs without fouling them.

Class C.—Conditions pertaining to the Motor.

9. A design and construction of electric motor, capable of withstanding the sudden and severe strains to which it will be subjected in working.
10. Gearing between the motor and the car axles that shall work as smoothly and silently as possible, and with little loss in transmission.
11. Electrical and mechanical fittings so arranged that the car can be driven in either direction from either end.
12. Freedom from complication, so that the whole of the machinery can be understood and managed by an ordinary workman.
13. Provision against serious damage in the case of any mistake being made by the driver.

Class D.—General Conditions.

14. Generation and control of the electricity ; provision for a variable production ; prevention of damage through short-circuiting ; and avoidance of lengthy stoppage in case of accident.

Description of Line.—The Blackpool line is nearly two miles in length. It is a single track, with ten pass-byes and one length of double line. The engine house and car sheds are placed near the centre ; this position was selected as being the most convenient, and as offering considerable advantages from an electrical point of view, compared with a generating station at one end. The roadway runs along the sea coast, facing directly west and exposed to the full force of the wind and tide from the Irish Sea. So strong are the periodical storms that, though the road level is well above ordinary high water mark, the waves dash over in such volumes that the road is flooded, and the doors and windows of the houses are occasionally beaten in ; during the winter months it is the custom to board up the doorways of many houses on the south shore. The difficulties in applying electricity underground in such a situation are therefore unusually great. When the tide is over the line, the current of course makes earth. At one time it was intended to employ accumulators for haulage during the floodings, and horses were occasionally used ; but owing to the amount of shingle brought over, the grooves in the rails were filled, and the cars kept running off. Working during the floodings has therefore been abandoned.

Only the positive electricity passes along the copper conductors. The return circuit is made by means of the rails ; and to ensure its being electrically good, each rail is connected by a strip of copper passing from rail to rail and plugged into holes punched in the ends.

Cars.—The cars are ten in number, and of various designs. The smallest are light open summer cars, seating thirty passengers. The largest are provided with transverse seats on the roof, and carry fifty-six passengers. The levers of the ordinary chain brake are placed outside the wheels, so as to leave a clear space under the centre of the car for the motor and the gearing. The mechanical construction of the motor was specially designed for allowing it to be fixed in a certain position. The bearings are held in a circular frame, large enough for allowing the armature to be passed through it.

Motors.—The motors are series wound, and of such proportions that they yield a high efficiency, running in either direction without giving any lead to the brushes. Reversal is effected by changing the internal coupling ; that is to say, whilst the current through the field is always in one direction, the current through the armature can be reversed, thus changing the relative polarity and consequent direction of motion.

Gearing.—To the circular frame of the motor is bolted the base of an elbow bracket, which carries the invert wheel gearing into a gunmetal pinion on the end of the armature spindle. The box holding the invert wheel has upon its back a chain pinion, from which the power is taken to the large wheel keyed upon the axle of the car. The elbow bracket can be turned upon its base, so as either to slacken or to tighten the chain at pleasure, without moving the motor or disarranging the centres of the armature pinion and invert wheel. But for the inevitable stretching of the chain, and the noise when new, this gear would be all that could be desired.

The electric driving of a tramcar involves more than the mere question of the reduction from high to low velocity. The wheels have to drive the car, not the car to take the wheel ; but as the car is heavier than the wheels, it is therefore better that the driving power should come from the car. If the motor were attached to the axles in order to obtain a fixed relation between the driving and the driven wheel, then the vibration would have serious consequences. If the motor be fixed to the car, then the multifarious movements due to varying load, springs, curves, uneven roads, stones, &c., all of which disturb the relation between the driving and the driven wheel, have to be compensated for. It has been argued that worm gearing is the most convenient for reducing a high velocity to a low one ; and also on the other hand that the loss in friction is fatal to the economical use of worm gear. The employment of worm gearing is a problem for which the writer believes that no reliable data exist or can be formulated ; it is a question of compromise, and the difficulty is to strike the happy medium. Experiments which he has made have given such satisfactory results that his intention is to adopt in future work the modification of worm gear which he has devised for the purpose.

Wiring.—In order to control the quantity of current and the consequent speed, resistance coils are employed, and are coupled with the switch-boxes placed under the car steps. A removable handle is used for driving, and a plug switch for reversal ; these are in charge of the driver, and when the car has completed its run in one direction he carries them to the other end of the car ; this plan prevents any accidental derangement, as it is impossible for the switches to be worked without them. The coils are arranged in series, and their resistance is about 4 ohms ; and most of the switches are of an ordinary type, cutting out 1 ohm

at a time. This method is open to the objection that the changes are not sufficiently gradual; and if a heavy current is allowed to pass through the final coil for a considerable time, it may become dangerously hot. It seemed desirable therefore that the switch should be so arranged that the coils could be used first in series and then in parallel, in order to obtain a more gradual change, and secure a larger surface for radiation when little resistance was in. A switch accomplishing this object is exhibited.

Generating Station.—As the cars have to work all day, the engines and dynamos are in duplicate, each set being capable of doing the full ordinary work, while in case of need both can be used at once. The engines are 25 nominal horse-power, compound non-condensing, of the semi-portable type, with locomotive boilers. A second-motion shaft is employed, in order that either or both of the engines may drive either or both of the machines. The dynamos are placed on a higher level than the engines, which enables the wheels controlling the friction couplings to be placed in a position where they can be worked conveniently by the engineman.

Generators.—The generators are four-pole shunt-wound dynamos; but instead of allowing any current from their own armatures to pass round the field magnets, these are separately excited by little machines. As the electromotive force of the external circuit varies directly with the intensity of the field, it can be regulated to a nicety by varying the resistance in the circuit of the exciter. This resistance is by preference placed in the armature circuit of the exciter. If the resistance were placed in the field of the exciter, the regulation of the electromotive force in the external circuit would probably be more complete; but the magnets of the generators would then discharge through the armature of the exciter, and there would be an extra current due to breaking the circuit of the magnets of the exciter. These extra currents would have a tendency to destroy the insulation, and would be otherwise injurious.

The controlling switch has ten points, and the corresponding resistances are as follows:—

Points.	Resistances.	Points.	Resistances.
1	21 ohms.	6	9 ohms.
2	18·5 „	7	6·8 „
3	16·1 „	8	4·8 „
4	14 „	9	2·4 „
5	11·5 „	10	0 „

The maximum electromotive force of the generators is 300 volts; and each will yield 180 ampères. They can when required be run in parallel. It is unnecessary to give the electrical details of these machines; but it may be mentioned that the total length of No. 17 wire (0·06 inch thick) on the magnets of each generator is about 14 miles.

Conductivity.—The sectional area of each copper tube represents a solid conductor of 0·575 inch diameter, giving a resistance of 0·165 ohm per mile. As there are two tubes running the whole length, and as the line runs right and left from the generating station, the total resistance may be taken as the joint resistance of two miles, which brings the calculated resistance down to 0·041 ohm. The actual resistance is much more than this, as is evident from the fall of potential over the line, as follows:—

Tram Shed, the electromotive force usually employed of 220 volts.
Foxhall, the junction with the main line... ... ... 210 „

Going North.	Volts.	*Going South.*	Volts.
South Pier	207	Manchester Hotel ...	204
Royal Hotel	204	Wellington Road ...	198
Lane Ends Hotel ...	198	Alexandra Road ...	189
Bailey's Hotel... ...	189	Waterloo Road ...	174
North End	185	South End	168

This fall is probably due to poor joints, faulty connections, &c.

Insulation.—Measurements were taken of the insulation of the line during construction, and 150 yards' length was found to give 4,490 ohms. But it has been practically impossible to measure the insulation of the finished line; for when the current is off, the condensation and moisture upon the insulators make the resistance very small. This after a night of heavy rain or sea flood causes a serious loss. When commencing work in the morning sometimes as much as 100 ampères is absorbed; but after running the engines for say half an hour the leakage will fall to 30 ampères. The average working loss through leakage may be taken at 25 ampères, which at an electromotive force of 220 volts is equal to 7·2 horse-power.

The principal difficulty arises from the shingle brought over by the tides, and the large quantity of fine sand blown into the channel by the high winds. At the commencement much trouble and annoyance resulted from the faulty construction previously referred to; but now by watchfulness and adjustment any hindrance to working can be avoided.

Efficiency.—No reliable measurements have been taken to ascertain the total percentage of loss in transmission, starting with the indicated horse-power of the engines and the mechanical power developed in propelling the cars. To arrive at this percentage it would be necessary to take a given number of cars of known weight, filled with passengers of known weight also, and to run them at the same time upon a given length of line of known gradient. When planning the works the writer assumed that the efficiency would be only 30 per cent.; but from the observations taken and the calculations of the different quantities, the actual efficiency is believed to be nearer 45 per cent. As the efficiency of the generators is about 90 per cent. and of the motors about 80 per cent., much further economy must not be looked for in them: though it should be possible for the loss in the generator to be not more than 5 per cent., and in the motor 10 per cent. The second-motion shaft in the present arrangement fulfils too important an office to be dispensed with; though by special engines and gearing the same object could be attained with less friction. It is exceedingly doubtful whether any form of gearing can be devised to absorb less power in transmission than that already described; indeed a larger percentage of loss might be allowed for the sake of simplicity and silence. The chief part therefore in which to look for further economy is the line itself; and in this the first point is more perfect insulation and consequently less loss in leakage; and the next is more perfect continuity in the conductors and therefore less loss through resistance.

Discussion.

Mr. Horsfall said he thought it his duty as chairman of the Blackpool Electric Tramway Company to endorse what Mr. Smith had said with respect to the difficulties which had been overcome. These difficulties arose in consequence of the defective manner in which the channels and other work had been executed by the engineers employed by the Borough of Blackpool, who were beyond the control of the company; one great difficulty was that which occurred in getting the collector to work along the centre channel, but that had now been overcome. As to the question of the economy of working the line, he had been at the trouble to take out some figures which might be interesting. For the week ending June 4th, their receipts were £67 1s. 1d., and the working expenses £30 18s. 4d., which included coal, tallow, waste, fireman's wages, as well as those of conductors, collectors, and inspectors of the line. For the last four weeks their receipts had averaged £330 per week, and the cost of material, wages, and everything else, had been about £45 in round figures. The total receipts since the opening of the line to August 27th, were £4,038 16s. 1d. That was including the winter months, when, he was sorry to say, the receipts did not pay the cost of working. He was in hopes, however, that during the coming winter, now that they had got over many of their difficulties, they would be able to pay the cost of working and make a profit for the shareholders. Personally, although he was not an electrician, as chairman of the company he had had a good deal to do with the line, and he must certainly endorse the views set forth by Mr. Smith. He believed that there was a great future for electric tramways in this country if they were properly managed. They had gained experience in Blackpool, unfortunately at a considerable cost to the company, which had spent in round figures about £30,000 in laying down the line; but he was quite sure that if another tramway were to be constructed, it could be done at a considerably less sum. The line was very popular at Blackpool, people crowding to get on the cars at every station. There had been no accident of any kind; the cars were stopped easily and in a short space.

Captain Douglas Galton said he had listened with great interest to what Mr. Holroyd Smith had had to say in his valuable paper. He would have liked, however, to hear a rather more detailed explanation of the cost of working such tramways; but as the lines had been put down so very recently that he imagined it would be rather difficult to get what would be a fair and reliable estimate of the working expenses. The system employed at Blackpool was not the only form of electric traction on tramways in operation. At Antwerp last year—and he understood that there were several carriages of the same kind put on to the tramways at Brussels now in active operation—the tramcars were worked by means of accumulators. He confessed that at first sight he thought that such a system, if it could be proved to be economical, would be preferable, because it did not seem to involve so large an outlay in the first instance, and he supposed there must be a certain expense in keeping the conductors clean. Perhaps Mr. Smith would say what that expense amounted to. He did not know that the experiments at Brussels had gone so far as to determine whether the system was a satisfactory means of traction. Certainly, at Antwerp the results were very satisfactory, but as the lines there were on perfectly level ground, and no hills had to be gone up, he did not think that those results could be taken as a fair guide of what the expenses might ordinarily be expected to be. In Brussels, on the other hand, the ground was hilly, which was a serious difficulty, but if it were found that the tramways there could be worked at a reasonable expense, notwithstanding the inclines, he thought that, as the result, very great additions might be expected to be made to electrical traction on tramways. They were of course just now in the experimental stage of the question, but there was one point which he thought was quite certain, and that was that most people would prefer to have electrical traction, which was most agreeable on tramways, rather than steam or horse-power, if it could be obtained at anything like a reasonable cost.

A Member said he wished to allude for one moment to a remark Mr. Smith had made with regard to the sand on the line. He happened to have lived by the seaside a great number of years, and he knew that there was hardly anything more calculated to fill up all kinds of space than sand when the weather was dry and the wind happened to be blowing from the sea. After a gale of wind, when the sand was in a dry position, it seemed to find its way into every cavity. Under such circumstances, he had found the rain pipes on his house filled from top to bottom, so that when

rain fell it could not run through them at all, and it appeared to him that with a strong wind blowing the working of the line might be seriously interfered with on that account. In the course of his reply perhaps Mr. Smith might say whether the tramway had suffered from that or not.

Sir FREDERICK BRAMWELL said he had not had the opportunity of hearing the beginning of the paper, and possibly Mr. Smith had given the information he desired, which was, the number of ampères required for the work at the varying points, or the average number, because he thought Mr. Smith spoke of a resistance of so great an extent that, having regard to the E.M.F., he should imagine that the number of ampères must be very small indeed.

Mr. TAIT said he was acting as county surveyor of Antrim at the time when the Giant's Causeway line was constructed, and he could not help thinking that £30,000 for a couple of miles of line at Blackpool was a very great outlay for so small an undertaking. It was quite clear for a variety of reasons that the underground means of providing electricity for tramcars, that was to say, if the electricity was not to be carried by the cars themselves, was a matter of very great importance for the future of that kind of locomotion. He did not think that the costs of the experiments either at the Giant's Causeway or on the line now under consideration could be fairly considered safe data to go upon, as they were merely tentative. There was one point in connection with the underground supply system which he would like to get more information about, and that was with reference to the clearing of the space in which the conductors were placed. What was the frequency of clearing, and what were the means adopted for clearing?

Prof. PERRY desired to offer his congratulations to Mr. Smith on the success which his system seemed to have attained. No outsider, nobody who had not had charge of work of that kind, knew the difficulties that an inventor met with in carrying out electro-mechanical inventions in the present state of electrical engineering. Mr. Smith was therefore to be congratulated, quite irrespectively of the cost of his electrical tramway, on being able to work it at all, because he had had to face very great obstacles. He (the speaker) confessed that the track was rather an expensive one. The method of making contact seemed to be very good where no accumulation of sand was likely to take place, but it was certainly a very expensive contrivance. Along with Prof. Ayrton he (the speaker) had patented certain contrivances which, in their opinion, would enable electric tramways to be worked efficiently. They had, however, got off just now on a side issue in a slightly different direction, in the development of some of those patents which came under the name of telpherage; and when one took up any particular line of investigation there was absolutely no power to take up anything else. One of the important contrivances that he referred to was one in which there was no opening whatever into the space where actual contact was made, the contact being effected from the tramcar outside. The internal contact of the actual conductor was made in the space to which nothing had access from the outside. With Prof. Ayrton he ran almost the first carriage that was run by electricity, certainly the first that was worked electrically on common roads; this was their electric tricycle. Both in London and in Paris they ran tramcars by means of accumulators, and at that time the weight—he would not say the cost—but certainly the weight of the accumulators was prohibitive. Perhaps some of the gentlemen present might be able to say whether the weight of accumulators and their cost had been so reduced as to make that plan of driving tramcars compete with any decent chance of success with this plan of Mr. Smith's. He would also like to know if Mr. Smith had had no difficulty with his motor. He felt that the most important thing that any electrical engineer—he thought he might say any mechanical engineer who knew a little electricity could devise for the benefit of humanity would be a motor which should have, he would not say any defects electrically, but which should have no mechanical defects. The way in which a man who might know electricity perfectly from a theoretical point of view, but who was ignorant of the mechanical knowledge necessary to give it practical effect, sometimes carried out his work was simply absurd. It could therefore be easily seen what mismanagement sometimes arose when an electrician had charge of the mechanical arrangements of a motor. Of course, though, when a mechanical engineer took charge of the invention there was a chance that some of the electrical arrangements might not be quite so good. Some of the telegraph engineers present might have noticed that Mr. Holroyd Smith said that the insulation resistance of the line was between 4,000 and 5,000 ohms. He had known telegraph engineers upon similar occasions say: "Oh, what a small insulation! Why, unless we had our telegraph lines a million times that resistance they would not work." Yes; but this was a tramway line. He (the speaker) considered that that was very good insulation for a tramway system. If a telegraph engineer would only figure out to himself how small an amount of power was being wasted in comparison with the tremendous power that was used, he would see that such a resistance was very satisfactory indeed. If that amount of power were wasted on a telegraph line, no message could be sent, but on a tramway its loss was not to be considered as of any moment.

Mr. LEACH believed from what he had seen of electric tramcars that they were perfectly under the control of those conducting them, and that they could not only travel with safety at a much quicker speed than steam cars, but they could be stopped almost instantaneously, while they were superior in this, that they were self-contained—not as in the case of the steam locomotive having an engine in front and the car behind, but having their accumulators stowed away under the seats. The accumulators, moreover, had been so much reduced in weight, that the objection to their use had practically disappeared. As far as he had been able to ascertain, tramcars driven by accumulators were a decided success, and he thought it was highly desirable now to try and discover its merits as compared with the plan now set before them.

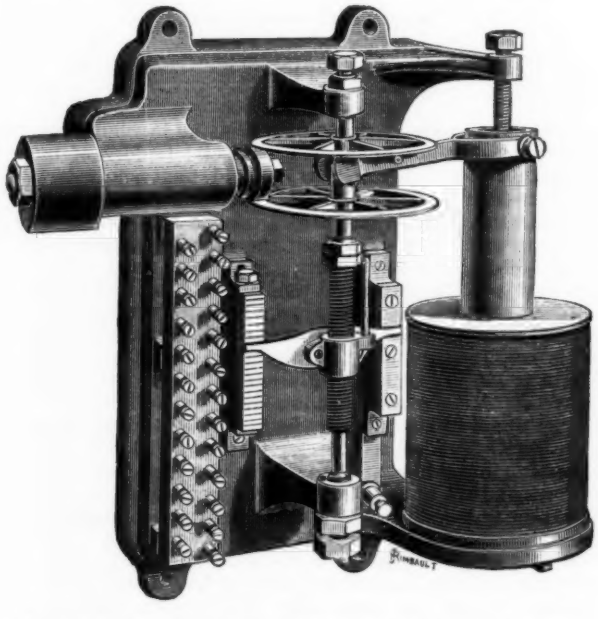
Mr. GISBERT KAPP drew attention to the fact that by the diagrams exhibited the loss of power was as great as 40 volts out of 200, which he characterised as being exceptionally heavy. He wished to know whether that would be the case under what would be considered to be satisfactory working conditions. Prof. Perry had referred to the fact that a great desideratum was a perfect mechanical motor. He (the speaker) had been of that opinion for a very long time, and had done his best to make one, but had failed. You might get a very good motor running at 150 revolutions, and you could make its mechanical efficiency very high, because with very high speed you could put pegs on your armatures and make a really good mechanical job of it. But what was wanted was a low speed motor, where every inch of surface could be utilised, and where you could put your mechanical device on and make the thing perfectly constant, and so avoid any sudden rush of current, consequently having no great increase of torque. In all motor work it must be expected that when the current was first turned on, if the motor were series wound, you would get the benefit of the exciting power of the magnets and the enormous torque. The thing started up with a rush, which was just what they wanted; they wanted most power when there was most current, but there was this sudden jerk, and the motors would not stand it. There were two ways of getting out of the difficulty: you might either employ a fast running motor which was mechanically perfect, when there would arise the necessity of reducing speed by gearing, or you might use a slow running motor, in which case you could not be quite sure that it would last through the work required of it. He wanted to know whether the gearing on the Blackpool service, which was evidently adapted for reducing speed considerably, was found to be in all respects satisfactory for working the tramway. What it was now chiefly desirable to get in connection with electric tramways was a high speed motor with noiseless and efficient gearing.

Mr. HOLROYD SMITH said that he was afraid if he replied fully to the numerous questions which had been addressed to him, his replies would occupy as much time as his paper. One of the first that occurred to him was that asked by Sir Frederick Bramwell. If Sir Frederick would kindly look through one of the papers he would find the information he desired respecting the number of ampères employed. The E.M.F. of the generating machines could be regulated to a nicety. Their maximum power was 300 volts and 100 ampères each, so that when they were running parallel they got plenty of current for the work. He found that the cars would take 15 to 40 ampères—that was to say, 40 when they were working up hill, and 15 to 20 when they were working on the ordinary roads. Mr. Kapp was perfectly correct in what he had stated in regard to the loss of power. The diagrams were not complimentary to himself as regarded the loss of E.M.F. He attributed the circumstance to the submersion of part of the line at certain periods in salt water. He quite agreed with Prof. Perry, to whom he was indebted for alluding to the fact, that they must not expect that high insulation in tramways—it was not necessary—that was required for telegraphs. In fact, the line in question would be, as far as insulation was concerned, practically good if the total insulation were only 100 ohms—quite good enough for practical purposes. The leakage when large currents had to be dealt with, such as in this case, of 250 to 300 volts—the resistance of 100 ohms was not of much moment. With regard to the system that Prof. Perry mentioned, namely, that of having a covered conductor and occasional contact made with it from the car, he (Mr. Smith) was not quite sure that he was acquainted with its details, but he knew the general idea of the plan, and he was afraid that Prof. Perry would find it almost impracticable if he put it into use. There were many practical considerations that were apt to be lost sight of when one was dealing with matters of this kind in the laboratory. He was afraid that as soon as contact was made they would make earth, and so the current would be lost. Respecting the subject of having good motors, he must confess that he had no small difficulty with that matter. He was unfortunately only a mechanical engineer, and the electricians would not place any trust in him, the result being that he had to leave electrical matters to others much more than he ought to have done; but he had found that ultimately the designs first laid down by himself and rejected by the maker had to be accepted and worked upon before the motors were made with any practical success. If they desired to get a high electrical efficiency a great many mechanical questions which it appeared not at all desirable to sacrifice had to be done away with. They were now getting 80 per cent. efficiency, and he held that to a great extent that was due to the simple contrivance he now held in his hand. Electricians had told him that it was out of the question to use such a thing as that. Now, however, there was little or no trouble with the brushes, and the commutators lasted for months, whereas they would not last for a week before. With respect to the gearing alluded to by Mr. Kapp and Prof. Perry, he must say that the gearing now working, but for the noise and the stretching of the chain, which he had already mentioned, would be perfectly satisfactory. The arrangements pretty well excluded the dirt, and he had been very careful about the teeth and the method of holding the wheel

within its shell. There had been no broken teeth up to the present time. The chains had been the principal drawback, but when any difficulty had arisen from that it had been been owing to an undue sense of economy on the part of the management. He had devised a worm gearing, and although he knew it sounded almost unorthdox amongst engineers to say so, one of the paragraphs in his paper showed that in his opinion the worm gearing was a subject upon which no reliable data existed, or could be stated. It was a question of compromise throughout, but if they could strike a happy mean, he thought with worm gearing they would have a great success. He really believed that properly designed worm gearing was going to be the most satisfactory for tramway work. That would give them what Mr. Kapp required, namely, a high speed motor and an absolutely quiet gearing. Mr. Horsfall, the chairman of the company, stated, and perfectly accurately, that the total cost of the Blackpool line was £30,000. Now, what he (Mr. Smith) had to deal with was not the cost of the line, but with the cost of the electrical part of the work. The whole cost of the channel, the engines and engine house, the generators, the wires, electric motors, the switches, instruments, &c., was under £12,000. As to the question of accumulators, he wished to state most emphatically that it was a delusion in the public mind that electricity was going to be put into a bucket the size of a hat, or only weighing about 1 cwt., and that then it was to do a great deal of work. A tramcar could not be worked with light accumulators. Supposing they had accumulators to work a line they would want three tons of them in each car, and they would have to be renewed three times a day. The total cost of fitting a line with accumulators would be 15 or 20 per cent. more than fitting it with a channel. The total cost of carrying 42,090 people in one week was under £45. He asked whether they could show in this or any other country a tramway worked at such a low rate. He was certain that it could not be done.

GOOLDEN-TROTTER PATENT REGULATOR

THIS instrument, which is strictly a mechanical, not an electrical regulator, is for the purpose of governing a dynamo, not an engine. Many engine owners will not allow their engines to be meddled with if they are good enough for their own purpose, but not good enough for the electric light. The instrument is usually constructed to give a regulation of 2 per cent.



for a range or variation of 50 per cent., that is to say, if the speed varies from 1,000 to 1,500, the volts will at no time, on a 50 volt circuit, vary more than 1, but it can be made for greater accuracy. It is also very useful, even where the speed is constant, for charging accumulators; the coil is then series wound and the spring adjusted for a certain current; this current will always be maintained. The volts of the dynamo charging the batteries are automatically adjusted to maintain this current while the back volts of the batteries rise. There is an entire absence of delicate parts about it, and it can be comprehended at a glance by any intelligent mechanic. Its action is as follows:—The small horizontal shaft is driven by means of a light cord or strap from any convenient part of the main shafting or the dynamo. On the end of this shaft is a small friction disc which gears into one or other of a pair of horizontal wheels, which are lifted in and out of a gear by the core of a regulating solenoid. This core, when the volts are too high, is drawn down, and, by means of a lever, raises one of the horizontal wheels into contact with the revolving disc; the wheel is consequently driven round, and turns a vertical screw which actuates a resistance switch, and inserts a resistance into the field magnets of the dynamo, thus lowering the volts to the normal pressure. In the same way, when the volts fall the core rises, being drawn up by a spring, allowing the upper horizontal wheel to gear with the disc; this revolves the vertical screw in the opposite direction, and so moves the switch that the resistance in the field magnet is lowered, thus raising the volts.

REVIEWS.

Exercises on Mensuration for Junior Students. By T. W. K. START, Assistant Master, Manchester Grammar School. London: Sampson Low, Marston, Searle, & Rivington.

This small book contains 300 carefully constructed questions (and answers), with general directions for their solution. The exercises have been adapted to the requirements of the Educational Code for the Examination of Pupil Teachers, as well as the Oxford and Cambridge Local Examinations. The utility of books of this class is unquestionable, and Mr. Start has done good service by publishing it. The questions selected are judiciously chosen and are of a practical nature.

Analysis Tables for Chemical Students. By R. L. TAYLOR, Teacher of Chemistry and Physics in the Central Higher Grade Board School, Manchester. London: Sampson Low, Marston, Searle, & Rivington.

This book (which is uniform with the foregoing one) contains a series of tables of a similar nature to those found in many books of chemistry; most of the tables are, however, accompanied by notes, wherein the various processes used in the tables for the separation and detection of the metals are fully explained. As a small handbook for those who wish to study chemical analysis the pages will prove of considerable value.

Gas for Motive Power and for Industrial Uses. (*Le Gaz pour Force Motrice et pour Usages Industriel.*) Paris: MAYER & Ce.

The object of this pamphlet is the advocacy of the so-called water-gas as a source of heat, to be utilised in a variety of industrial processes, and in particular in working gas engines, such as the Otto. Water-gas, as the majority of our readers are doubtless aware, is obtained by passing steam, or watery vapour, over coke at a very high temperature. The water is thus decomposed, its hydrogen being set free and its oxygen combining with the carbon of the coke to form carbon monoxide, formerly known as carbonic oxide. These two constituents are present in the product in nearly equal proportions. The entire mixture obtained is combustible and burns with a pale flame, giving out great heat, but owing to the absence of olefiant gas and other so-called illuminating hydro-carbons. This absence, where the production of heat is the object in view, is a distinct advantage. Ordinary coal-gas burns with a smoky flame which in most chemical operations is a decided drawback. Hence has arisen the necessity for the Bunsen burner, which ensures a complete combustion without a deposition of soot.

It is also claimed in the pamphlet before us that water-gas contains a much smaller proportion of sulphur compounds than does coal-gas. If this exemption is general the advantage is not trifling, since, when coal-gas is used in chemical and metallurgical operations, it often occasions serious mischief by introducing sulphur where that element is by no means wanted.

Lastly, water-gas is much cheaper than coal-gas. In its production the plant, materials, and labour required in the purification of ordinary lighting gas do not figure, and hence, we presume, its manufacture will be approximately at least free from nuisance.

Now, it cannot be denied that in these days a cheap, gaseous fuel, which should generate no smoke or soot, leave no ashes and evolve no sulphurous acid would be an incalculable boon, especially in our large cities. Hence the claims of water-gas as a source of heat deserve a very careful examination.

The question must of course arise: What, if any, are the accompanying drawbacks? It must be at once admitted that the manufacture of water-gas yields none of those saleable by-products which at one time figured so largely in the returns of gas companies. It was at one time even suggested that the distillation of coal might be advantageously carried on for the production of coke, ammoniacal salts, and tar, the gas being treated as a mere secondary matter to be utilised as opportunity might offer. The last few years, however, have quite dispelled this prospect. Coal-tar is again a drug in the market as it was before the invention of the aniline colours, and sulphate of ammonia is worth little more than half what it was ten years ago. Hence the fact that the manufacture of water-gas yields no by-products is, for the time being, rather in its favour than otherwise.

Another disadvantage of the new gas is, however, more serious than the authors of the pamphlet before us are willing to concede. Its propagation of the deadly gas carbon monoxide is much greater than that occurring in coal-gas. That in coal-gas varies from 6 to 10 per cent. In water-gas, according to figures quoted in this pamphlet, it may range from 35 to 50 per cent.! This is a very grave intensification of danger. The flippant remark of the authors, L. Van Effenterre and T. Thiercelin, that the gas is not "meant to be inhaled," is quite beside the question. Coal-gas is likewise not "meant to be inhaled," but it is inhaled from time to time and occasionally with fatal effects. What guarantee have we against the escape of a gas so much more dangerous, and which does not, like coal-gas warn us of its presence by a powerful smell? The authors indeed propose to communicate a smell to water-gas, though they do not state distinctly what means they propose to adopt.

If water-gas is brought into use, a consummation which from all other points of view is much to be desired, the most jealous care will be necessary in its use.

It may be asked how we come to be interested in this "burning question," as the authors style it? The answer is simple: a cheap source of power must be obtained to drive the dynamos if the electric light is ever to come into general use.

Elements of Electro-Technics. (*Elements d'Electro-Technique.*) By ERIC GERARD, Professor at the Montefiore Electro-Technical Institute, attached to the University of Liége.

Notes of Lectures delivered by the Author at the Liége Mining School. Edited by LEON DEMANY. Liége: Vaillant Carmanne.

This voluminous work opens with an introduction expounding the principle of the conservation of energy and the system of absolute units. In successive chapters we find a summary of the principles of electric, magnetic, and electro-magnetic phenomena; the applications and extensions of Ohm's law and generalities on voltaic batteries, and the instruments and methods of electric measurements.

The fourth chapter is devoted to electrolysis, batteries and accumulators. The author admits, of course, that the electricity furnished by batteries is very costly. He considers, however, that although the figures relative to the price of the work are not at all encouraging, the battery may yet perhaps become the electric generator of the future. At present we consume in it zinc, but we may hope to succeed in utilising much less costly materials in its place.

Thermo-electric batteries are discussed in the fifth chapter. The author shows that as regards yield, such appliances are far inferior to chemical batteries, as the useful electric work furnished by the thermic generator represents only a small fraction of the heat expended in raising the temperature of the soldered points.

The next chapters are devoted to magnetisation, electro-magnetic action and induction; to dynamos, electro-motors and transformers, in which the instruments of Gaulard and Gibbs, and of Zipernowski-Déri-Blathy are described and figured.

In the eleventh chapter we find an account of what has been effected in the electric transmission of power. The author considers that the danger of high tensions, though real, has been exaggerated. He quotes the dictum of Sir W. Thomson that a machine which develops electricity at a high tension is not more dangerous than a circular saw. We find a description of the experiments of Marcel Deprez at Munich-Miesbach, on the Northern Railway at Paris, in 1883, and at Grenoble in the same year. The more recent experiments between Paris (La Chapelle) and Creil are not noticed.

The author then passes on to electric traction, telegraphy and telephony, and the electric light, electro-metallurgy, and the distribution of electric energy.

An appendix contains a number of useful tables.

The work, as a whole, may be pronounced a clear, well-arranged compendium of modern knowledge concerning the practical applications of electricity.

NOTES.

The Newcastle Exhibition.—We understand that electric lighting is to be made a special feature of the Royal Jubilee Exhibition to be held next summer at Newcastle-upon-Tyne, and it is the desire of the Electric Lighting Committee to illustrate as many different systems as is consistent with the efficient lighting of the building and grounds. A model coal mine, lighted with incandescent lamps, will be among the objects of special local interest; and as Tyneside must be regarded as one of the homes of the electric light in this country, we may hope that, as far as the electric light is concerned, the exhibition will be in advance of any that have hitherto been held. The buildings will cover about 250,000 square feet, and will surround a garden of about three acres. Lithographed copies of the plan and sections of the building have been prepared, and we understand that the committee will be glad to send them to any electric lighting company or firm who may be willing to light any portion of the building or grounds. It is necessary that all proposals should be in the hands of the Electric Lighting Committee before the 28th inst. Applications for particulars should be addressed to "The Secretary, Exhibition, Newcastle-upon-Tyne."

An Electrically Lighted Oil Steamer.—The new German steamship *Gluckauf*, which arrived at New York recently from Newcastle, was built expressly for the oil traffic, and will carry oil in bulk across the Atlantic. The *Gluckauf* measures 2,297 tons gross and 1,508 tons net; she is 299 feet long and 36 feet beam. The engines and boilers are in the after part of the vessel, and are cut off from the oil tanks. In order to insure further safety, the vessel is lighted throughout by electricity.

Electric Lighting in Mills.—Messrs. G. N. Russell and Son's large corn mill and store in Henry Street, Limerick, have just been completely fitted throughout with the electric light, the installation consisting of 200 lamps, each of 20 candle-power each. The dynamo, giving an output of 100 volts and 60 ampères, is driven by one of Hindley's horizontal steam engines, the belt being direct from pulley of engine to dynamo, as the speed of the latter is only 900 per minute. The arrangement of switches throughout this installation is particularly noticeable. Near the dynamo is placed a large mahogany switchboard, on which are all the main switches for the various departments, the names being written on brass plates under each. The entire current first passes through a Woodhouse and Rawson automatic cut-out, which is so adjusted that if more than the proper quantity of lamps are turned on the circuit is broken, thus preventing the machine from over-heating; this is necessary, as at present only a 100-lighter is used for the 200 lamps. On each floor of the mill is placed a specially-designed lever-switch, which can be turned on or off by cords from various parts of the mill. The lamps, which are run in double parallel, have plug switches attached to every second one. There are also twenty portable lamps in heavy brass hand lanterns; these are attached by specially thick flexible cords to teak bosses screwed against the pillars of the building; the bosses have a large binding post, and a copper hook is fastened to the loose end of the flexible cord, so that by placing the hook into the binding post the lamp is lit; all these lamps are of the 100-volt type, and are, of course, run in single parallel. It is intended to place another 100-light machine down, so as to be able to run the entire number of lamps at the one time. The installation was carried out by Mr. C. C. MacCarthy, of Belfast.

Electric Lighting in the Post Office.—After a lapse of nearly 18 months, the authorities at St. Martin's-le-Grand have decided again to endeavour to light the central telegraph and other offices in the City by electricity. With this object in view the authorities, having obtained the sanction of the Lords of the Treasury to the increased expenditure that will be incurred in adopting it, are making arrangements now to light electrically a portion of the galleries only; the galleries selected for the experiment being the central hall, on the ground-floor, which is entirely devoted to the foreign branch and the pneumatic tube working; the news department and the special events section, situated on the top floor, and stated to be the busiest departments of the central office. To add to the success of the undertaking, Mr. Probert, one of the Post Office electricians, has been specially selected to carry out the experiment, and has already entered upon his duties. Should the light be successful, the authorities, it is stated, contemplate the adoption of it throughout all the galleries and other parts of the central telegraph office, the General Post Office, and the other large buildings under their jurisdiction in the City. It is expected that the mechanical arrangements will be ready for use on the 1st prox., which will be the first anniversary of the adoption of the sixpenny telegrams.

The Royal Courts of Justice.—In answer to Mr. Pickersgill in the House of Commons on Friday last, Mr. Plunkett said it was impossible to begin the work of extending the electric lighting to the Bar library at the Royal Courts of Justice while the Courts were sitting. The necessary arrangements were now being made and would, he was assured, be completed before the close of the Long Vacation.

Electricity at the Yorkshire College.—The last section of the new buildings of the Yorkshire College at Leeds, viz., the department devoted to civil and mechanical engineering, is nearly completed, and will be opened early in the coming month. Among the subjects included in the curriculum will be theoretical and practical electrical engineering.

Tivoli Lighted by Electricity.—The unique example, according to the *Times*, of a town undergoing direct transition from oil lighting to electric illumination without passing through the intermediate stage of gas lighting is presented by the little town of Tivoli, near Rome. The installation has been carried out by the Hydraulic Power Company, of Rome, the motive power being water, which drives two turbines, which in turn drive two powerful dynamos for producing the current. The primary circuit is 29 kilometres, or about 18 miles in length, and the town is illuminated by means of 225 glow lamps of 50 candle-power each, the Town Hall being lighted by 76 glow lamps of 16 candle-power each. Distributed over the town are also six arc lamps of 500 candle-power each, carried on wrought iron standards some 70 feet high. The secondary generator of Messrs. Gaulard and Gibbs is used for distributing the current, a small generator being affixed to each lamp. These generators are of a type specially adapted for street lighting. Upon the occasion of the inauguration of this installation a large number of invited guests from the town and from Rome were received by the Municipality and citizens. The guests included the representatives of England, Spain, Austria, and other nations, and after the motors had been started and the city illuminated a grand banquet was partaken of in honour of the occasion and was followed by a musical entertainment in the Town Hall. The success of the lighting is complete and reflects credit upon the Hydraulic Power Company of Rome. Arrangements are being made for private lighting in Tivoli and for transmitting 2,000 horse-power from Tivoli to Rome for lighting purposes in the latter city.

The Electric Light at Bournemouth.—As a result of the successful electric lighting experiments mentioned in our last impression, a meeting of tradesmen was held at Bournemouth a few nights ago for the purpose of considering the desirability of adopting the light for business requirements. The matter was discussed at length, and Mr. Shepherd (Mortimer, Shepherd and Co., of London) stated that the electric light could be supplied at a cost a little above that of gas, but if it was generally adopted it could be produced even cheaper. It was eventually suggested that a syndicate should be formed to carry out experiments for one year, with the view, if successful, of afterwards forming a company. The cost of this experiment was estimated at £1,000, and it was also anticipated that a loss of £250 would accrue to the first year's working, which might be carried forward to the account of the company. Mr. Shepherd intimated that he was willing to undertake the personal supervision of the undertaking, and he thought that if they could guarantee about 500 lights there would be a fair return for the first year's outlay. Subsequently it was resolved to appoint a sub-committee to canvass the town, so as to ascertain what support was likely to be obtained for the use of the light and for raising the necessary finances. It is to be hoped that the result of the canvass will be successful, as an extended adoption of the electric light could not fail to be of benefit to Bournemouth as a town. It would be of great advantage in rendering the pier more attractive, and in according more light to the Square and Public Gardens, which at present are rather in need of it. Those who have already given it a trial are very decided in their opinion as to the inferiority of gas. Drapers value it the more highly, because they are enabled to match colours after dark, while its cleanliness and the absence of deleterious influences on goods are generally commended.

Electric Lighting at the Leeds Musical Festival.—The committee who are organising the Musical Festival to be held at Leeds in October have decided that the hall in which the performances take place shall be lighted by electricity in the form of incandescent lamps. The installation will be set up by Mr. Wilson Hartnell, the Leeds representative of Messrs. Crompton and Co., at whose disposal the Electric Lighting Com-

mittee of the Corporation have placed all their plant. In this connection it is interesting to remember that the Town Council of Leeds, having applied for a Provisional Order under the Act of 1882, declined to carry it out because of the compulsory supply exacted by the Board of Trade; but subsequently appreciating the importance of the subject, they authorised the expenditure of £10,000 on experimental electric lighting, and as a result have adopted this light for some of the public buildings.

Eastern Telegrams.—The Eastern Telegraph Company has been advised that the route *viâ* India and the Siamese land lines is no longer available for telegrams to the far East.

West African Cables.—The African Direct Telegraph Company states that its station at Bonny, on the West Coast of Africa, is now open and served by direct cables from England at a charge of 9s. 8d. per word. Telegrams for Bathurst, Sierra Leone, Accra, Lagos, Brass, or Bonny should be sent from the Eastern Telegraph Company's offices, London, Liverpool, Manchester, and Glasgow, or directed *viâ* Eastern from any postal station in Great Britain and Ireland.

University College, Bristol. — The session 1886-7 will begin on 5th October. Lectures and classes are held every day and evening throughout the session. In the chemical department lectures are given and classes held in all branches of theoretical chemistry, and instruction in practical chemistry is given daily in the chemical laboratory. Excursions to some of the mines, manufactories, and chemical works of the neighbourhood are occasionally made. The department of experimental physics includes various courses of lectures arranged progressively, and practical instruction is given in the physical and electrical laboratory. The department of engineering and the constructive professions is designed to afford a thorough scientific education to students intending to become engineers, or to enter any of the allied professions, and to supplement the ordinary professional training by systematic technical teaching. This department includes courses specially arranged for students intending to become civil, mechanical, electrical, or mining engineers, surveyors, or architects. Those who attend the mechanical engineering course enter engineering works during the six summer months, and in accordance with this scheme, various manufacturing engineers in the neighbourhood have consented to receive students of the college into their offices and workshops as articled pupils; the engineering laboratory is provided with a powerful testing machine, and instruction in the use of tools is given in the workshop. Special courses in surveying are given, and excursions for field practice are frequently made. The department for geology, biology, and zoology includes various courses of lectures in all branches of those subjects, together with laboratory instruction. In the botanical department practical instruction is given by means of the botanical gardens, which contains upwards of 1,000 specimens. Courses of lectures are given and classes held in mathematics, political economy, logic, moral philosophy, modern history, English literature, Greek, Latin, Hebrew, French, and German. Medical education is provided by the Bristol Medical School, which is affiliated to the college. Several scholarships are tenable at the college.

Electric Bell Fitting and Maintenance. — Next month a course of evening instruction of special importance to bellhangers, whitesmiths, gasfitters, and ironmongers, will be commenced by Professor Silvanus Thompson at the Finsbury Technical College. This course will be a practical one, and laboratory practice will be provided, no previous knowledge of electricity being required. The lectures will be six in number, and will deal successively with batteries, bells, lines, pushes, switches, and annunciators, circuits and testing, and special bells and fittings.

Electroplating.—To meet the wants of machinists, ironmongers, electro-platers, and others, who desire to obtain a theoretical and practical knowledge of the electro-deposition of metals, a course of six lectures will shortly commence at the Finsbury Technical College. Professor Silvanus Thompson will be the instructor, and students entering for the course will be divided into groups, each group receiving independent instruction. The lectures will be devoted to the modern practical processes of nickelplating, steelplating, coppering, electro-brassing, electro-plating with silver, electrogilding, &c. Practical laboratory instruction will be provided as supplementary to the lectures.

The Waterbury Watch and Magnetism. — Prof. Jamieson, A.M. Inst. C.E., F.R.S.E., Principal of the College of Science and Arts, Glasgow, says:—"I inserted a Waterbury watch between the magnetic poles of a ten horse-power dynamo. Of course, the watch instantly stopped, but on being started again I regulated it only twice within two days, and have found that for one whole month it did not vary two minutes from correct Greenwich time. I now prefer it to my former and much more expensive watch, and consider it an excellent timekeeper for workmen and others connected with electric lighting."

Mr. Arthur Hoare writes:—"I have had a Waterbury watch for a year, during which time I have been amongst powerful dynamos and motors, being constantly engaged in superintending their working. My watch has gone beautifully the whole time and does not seem to be affected in any way. If it is placed upon the magnets of a 50-unit machine it stops instantly, showing that, strictly speaking, it cannot be called non-magnetisable. The watch can afterwards be started again and, as I said before, has always gone splendidly. I hope this may be of use to your readers."

The experiences related above are borne out by our own, now extending over a period of nearly a year.

A New Battery.—A so-called "new" battery has recently been brought out by a Mr. P. Germain. This battery consists of a plate of amalgamated zinc placed above and resting on a mass of a material rejoicing in the name of "cofferdam;" the latter substance holds in its pores a solution of sal-ammoniac, beneath the "cofferdam" is placed a carbon electrode surrounded with granules of peroxide of manganese. The whole is enclosed in a wooden box. By means of contact springs the plates are kept pressed together. According to the prospectus of the invention, a casual observer would be inclined to think that the new battery was very like a Leclanché. We are also inclined to this belief, the battery is certainly *very* like a Leclanché. The inventor states, however, that owing to the marvellous action of the material "cofferdam," the chemical action which takes place differs materially from that which occurs in an ordinary Leclanché, the result being that the new battery is "infinitely" more economical than the Leclanché. According to a statement, one of the Germain elements worked an electric bell for over 4,600 hours, when an ordinary Leclanché failed at the end of 292 hours, the working conditions in the two cases being the same. We should like to hear more about the invention, about the "infinite" superiority of which we are sceptical.

Naval Uses of Electricity.—The United States new steel cruiser *Atlanta*, which has been built in a most thorough and elaborate manner, is to be fitted with electric incandescent lights. The *Scout*, twin screw torpedo cruiser, about to be commissioned at Portsmouth, has been fitted with two search lights and a complete system of internal electric lighting.

Centenary of Galvani's Discovery.—On September 3rd a banquet took place in Bologna to celebrate the 100th anniversary of the discovery of animal electricity in that city by Galvani.

Henley's Telegraph Works.—The directors of Henley's Telegraph Works have just added two new test rooms to the well-known North Woolwich factory. There is now in course of completion in the works some 250 miles of deep sea cable for a Submarine Telegraph Company, and we know of no reason why orders for cable to any extent cannot now be carried out by Henley's Company, under the energetic direction of the manager, Mr. Hatton.

The Blackpool Tramway.—During the week before last the number of passengers carried on the electric tramcars at Blackpool was 44,306 ; the cost of fuel (coal and coke) was £4 16s. 3d. ; the total receipts were £347 15s. 3d., and the working expenses £45 16s. 2d. The number of miles run was 2,760.

Gas Engines.—The committee of the Novelties Exhibition of the Franklin Institute, held last year, has awarded a silver medal to the Stockport gas engine, and a bronze medal to the Clerk gas engine.

Medical Applications of Electricity.—Mr. George Lichtenfeld has brought out a novel application of electricity to be applied to the scalp of the head for curative purposes. The appliance consists of a small battery, preferably of the silver chloride type, with fine flexible conducting wires and terminal plates. The object of the application is to relieve headache, neuralgia, and nervous affections generally. The entire weight of the battery including conducting wires and terminal plates is from one to three drachms, and can be worn in connection with any head covering without giving the slightest inconvenience to the wearer. By means of the terminal plates the current of electricity is conveyed direct to the scalp of the head, and it can be instantly stopped by removing the terminal plates from the skin, or by placing them amongst the hair. Several medical gentlemen who have paid some considerable attention to this invention, are of opinion that it will be very beneficial to the aforesaid nervous affections. In our opinion it is one of the neatest things of the kind which has ever been brought before our notice. The battery, although so small, is sufficiently powerful to ring a trembling bell or to actuate a small induction coil.

The Dangers of Overhead Wires. — A singular accident occurred at King's Cross on Wednesday evening last week. Mr. Eden (manager of the Clerkenwell branch of the National Bank,) Mr. Kellaway (churchwarden of Clerkenwell,) and Mr. Johnson (Clerkenwell vestryman,) were standing near King's Cross Station, when suddenly a telephone wire fell upon their heads, coiled around the churchwarden's hat, and damaged the hats of his companions. The wire was fastened to the nearest lamppost, and the Telephone Company apprised of the occurrence, when it was stated that the wire had been dropped by a man who was carrying out repairs. Some years since a man was killed not far from the spot by a falling telegraph wire coiling round his neck.

The Electric Railway at Ryde.—This enterprise, which was started some time since by the directors of the Ryde Pier Company, is becoming a great success, its novelty and utility ensuring a large amount of patronage by visitors to the Isle of Wight. We are informed that the increase of traffic during the past five months has been 40,502 over the corresponding period of last year. This ought certainly to convince the advocates of the clumsy wire-rope system that the majority of the shareholders were right in deciding in favour of electricity.

Electric Light Cable.—At Tuesday's meeting of the Commissioners of Sewers the clerk read a letter from Messrs. Verity Brothers, asking permission to lay cast-iron pipes under Pancras Lane, for an electric light cable in connection with 26, Queen Victoria Street, and 3 and 4, Bucklersbury, which was agreed to.

Railway Signalling Apparatus.—We have received a description of a railway signalling apparatus, the invention of Messrs. W. Rice and W. Sykes, the primary object of which is to give greater protection to the travelling public by establishing on the railway a series of signalling points from which the officials at the stations to the left and right can be informed of any accident or breakdown. The general principle of the arrangement, we would state, is one which is many years old, and, moreover, is one which has more than once been suggested. A system on the principle was adopted on the London and North Western Railway in 1854 by Mr. Edwin Clark, but no advantage attended its adoption, and it was, after no great length of time, abandoned. Not only do all such contrivances add greatly to the cost of construction, but they are a fruitful source of interruption, and, at the best, merely intimate, perhaps a moment or so earlier, that which the non-arrival of the train (which it should be remembered is always signalled in advance the moment it enters a block section), or the absence of a signal to that effect would convey to the signal boxes at either end of the section. The inventors suggest that the lines for their purpose would serve for ordinary signals between the two stations ; anyone who is acquainted with the requirements of the simplest form of block signalling (which is now practically universal) would know that such an arrangement would be quite out of the question.

Electrical Work in Workhouses. — The Chorley Board of Guardians have decided to connect the workhouse hospital and master's rooms by telephone, and the different wards and attendants' bedrooms by electric bells, and have decided to purchase outright the Gower-Bell Telephone instrument in preference to rental. The work has been entrusted to Mr. G. Sharples, of Preston.

Colonial and Indian Exhibition.—On and after the 18th instant, the Exhibition will be closed at 10 p.m. on Saturdays, instead of 11 p.m. as hitherto.

The School of Electrical Engineering, Hanover Square.—At the recent final examination for the certificate of this school, conducted by Mr. H. R. Kempe, of the Engineer-in-Chief's Office, G.P.O., the following gentlemen obtained above 70 per cent. of full marks ; and as they had already passed the examination in engineering, the certificate of the school was awarded to them :—B. M. Jenkin, W. G. A. Bond, E. J. T. Ryves, G. H. Robertson, J. D. Dallas, L. C. Login, W. Peto, F. L. Todd, J. W. F. Ashwin, W. A. Coulson, C. A. Baker. This list comprises one-half of those who went in for the examination. The two divisions of the elementary class were examined at the same time by Mr. Kempe. In the senior division 8 out of 17 students gained 75 per cent. and above, of full marks ; 4 more getting 60 per cent. and above. In the junior division, 11 students out of 17 gained 50 per cent. and above, of full marks. These figures show a high degree of efficiency in the school, and justify the favourable comments of the examiner, expressed in a letter to the Manager (Mr. C. W. Lant Carpenter, B.Sc.).

The British Association Papers.—With reference to the paper "On a New Scale for Tangent Galvanometers," published in our issue of the 10th (page 257), we are somewhat surprised that Sir William Thomson expressed the opinion he did with reference to the originality of the new scale. We have carefully read Sir William's patent specification, to which he referred, and fail to find in the same any description of a scale at all corresponding to the one in question.

Contracts for Carbons.—Tenders are required for the supply of about 30,000 carbons. Full particulars on application to Messrs. J. Waddell and Sons, 17, James Street, Liverpool.

Submarine Mining and Electricity. — Important experiments in the explosion of submarine mines were conducted off Portsmouth on Tuesday. Electrical means were of course adopted, and the experiments went clearly to establish the efficiency of the system.

Army Telegraphs.—The Telegraph Division showed to advantage at the important field operations at Aldershot last Tuesday. Actual lines were laid and messages transmitted over them. Prince Albert Victor displayed great zeal during the day, nearly every line of telegraph being personally supervised by him.

Submarine Cable Protection.—Amongst the business transacted in the early hours of Tuesday morning and not publicly recorded, was the enactment of a Bill, moved by the Secretary of the Board of Trade, and entitled the Submarine Cable Amendment Bill, 1886. The object of the measure is to ratify the International Convention for the purpose of material protection being accorded by all the Powers respecting the submarine cable system of the world. Until the Bill became law the decision of the International Conference was inoperative.

Blenheim's Patent Telephone.—A new telephone has been recently brought out by Messrs. W. Blenheim and Co., of Englefield Green, Egham, which, in regard to construction, fixing, and maintenance, is as simple as an ordinary electric bell. The arrangement consists of a small electro-magnet and armature attached to a membrane of non-inductive material with a battery in the line ; carbon tension-regulators and diaphragms, permanent magnets and iron tympans, being all dispensed with. The articulation is both loud and distinct, and the instrument is said to be quite satisfactory any distance up to ten miles.

A New Scale for Tangent Galvanometers. — Mr. Sydney Evershed writes (too late for our correspondence columns) :—" Under the above heading Messrs. Preece and Kempe announce another 'discovery' by 'one of the electricians of the Post Office.' I do not deny that the new scale is a discovery, so far as the Post Office is concerned, but should like to point out that the skew method of using tangent and other galvanometers has been known to the benighted outside world for years—how many I cannot say. It is now two years since Mr. Swinburne pointed out to me the great advantage of a skewed controlling field in nearly all measuring instruments ; since then I have applied the principle to some half dozen different types, including a tangent instrument."

The Marchant Engine.—We beg to draw the attention of our readers, especially those engaged in any manner with steam engine construction, to the description of and tests made with the Marchant engine which appear in this issue of the REVIEW. The subject of fuel consumption is one the importance of which need not be enforced by us. It is of the greatest interest to electric light engineers ; and we shall be pleased to publish any comments or criticisms on our article.

An Electric Light Station Destroyed.—A serious fire occurred on the night of the 16th ult. at the Brush Station in Elizabeth Street, New York. The fire began on the second floor of the three-story building, and in four minutes from the time of the alarm at 7.28 p.m. the entire three-story building was in flames. The three-story building was once a soap factory, and was soaked with grease. A slack pressure of water hindered the work of the firemen greatly. The lights that this plant was supplying directly were switched off before the firemen arrived. Altogether the Elizabeth Street plant and the station in West Twenty-Fifth Street were running 1,200 lights. They served the city in Fifty-Ninth, Forty-Second, and Fourteenth Streets. Broadway, Fifth Avenue, and Seventh Avenue, many of the private arc lights in the Bowery, and private arc lights from Fourteenth Street to the battery. The West Twenty-Fifth Street station was still serving 400 lights between Fifty-Ninth and Fourteenth Streets when the firemen got to Elizabeth Street. At the outbreak of the fire the electric light company connected the eastern system with the western by a switch at the Bowery and Fifth Street, but the firemen feared that in their wet clothing they would be in danger at their work with the wires operative, and orders were telephoned up to Twenty-Fifth Street to shut down the eastern section, and this was done. Superintendent McGrath, who was out of town, was notified of the occurrence and came in immediately. He soon put matters in shape, and by midnight nearly all the lights of the Elizabeth Street Station were being run by the Twenty-Fifth Street station. The latter station will temporarily operate the entire Brush plant. The property destroyed was insured.

An Electric Organ. — St. John's, Bathwick (near Bath), has recently had its electric organ thoroughly cleaned and repaired by Messrs. Jones and Sons, of South Kensington. A new stop—the tenoroon—has been added to the fine instrument, which gives weight and colour, although a soft stop of 16 feet. New pedals of birch have also been introduced, the total cost of the work being £100.

NEW COMPANY REGISTERED.

Blakey, Emmott and Company, Limited.—Capital : £35,500 in £100 shares. Objects : To purchase the business of electrical and general engineers carried on at Square Road, Halifax, by Messrs. Edwin Blakey and Walter Emmott. Signatories (with 1 share each : Edwin Blakey, Walter Emmott, Halifax ; James Lakeman, Leeds ; E. H. Fowle, Penkridge, Stafford ; Edward Butler, S. Wilson & Co., P. Spink, Leeds. Until the first directors are appointed the signatories are to act as directors ; qualification, 1 share. Each director residing within 90 miles of the place of meeting will be entitled to two guineas for each meeting he may attend, and such of the directors as reside beyond 90 miles will be entitled to four guineas per meeting ; directors will also receive travelling and hotel expenses. A further sum of £20 will be paid to each director for every 1 per cent. dividend upon the ordinary shares in excess of 10 per cent. per annum ; but such further sum of £20 shall not in the aggregate exceed the sum of £1,000 per annum for each director. Messrs. Edwin Blakey and Walter Emmott are appointed managing directors, at salaries of £600 per annum each, together with the same augmentation for each 1 per cent. dividend above 10 per cent., as in the case of the ordinary directors. Registered 8th inst. by Messrs. Waterlow Brothers and Layton, as agents for Messrs. Butler and Middlebrook, solicitors, of Leeds. Registered Office, Square Road, Halifax,

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Woodhouse and Rawson Electric Contract and Maintenance Company, Limited.—An agreement of 8th inst. (registered on the 9th inst.) provides for the allotment of 250 fully paid shares of £10 each to Messrs. Otway Edward Woodhouse and Frederick Lawrence Rawson, of 11, Queen Victoria Street, and 250 fully paid shares of £10 each to the Crossley Telephone Company, Limited, in pursuance of an agreement of 31st ult.

William Elmore, Limited.—At an extraordinary general meeting of the members of this company held at the company's offices, 24 and 28, Charlotte Street, Blackfriars, on the 6th inst., it was proved to the satisfaction of the meeting that the company, by reason of its liabilities, cannot continue its business, and it was resolved to wind up voluntarily. Mr. William Bourne, the secretary of the company, is appointed liquidator at a remuneration of £250 per annum. The resolution was filed on the 8th inst.

LEGAL.

Fuller and Son v. Buller, Jobson and Co.—This action came before Mr. Justice Stirling (sitting as vacation judge) in the Chancery Division of the High Court of Justice, on Saturday the 11th inst., in the shape of an application for an interlocutory injunction against the defendants, who carry on business in Birmingham, to restrain them from infringing certain patent rights alleged to be vested in the plaintiffs, for the manufacture of improved telegraphic insulators. The action itself was one for the specific performance of an agreement dated the 15th of March last, made between the plaintiffs and defendants with a view to settling the point as to who was really the patentee of the patent insulator in question, and clauses 3 and 4 of such agreement respectively provided that the defendants, Messrs. Buller, Jobson and Co., should not tender for or sell the insulators without the plaintiffs' consent, and that they should have at the plaintiffs' convenience opportunity for so tendering and contracting for the sale. The agreement of the 15th of March was not disputed, but the defendants set up a supplemental agreement of the 16th of April, by the covenants of which they contended they were entitled to tender for the supply of the insulators without the plaintiffs' previous consent, upon payment of a certain royalty to be afterwards ascertained. The plaintiffs, however, denied that such an arrangement had been ever entered into by them, and in the result, his lordship held that there had been no final or binding agreement made in April, and that the defendants must be restrained under clause 3 of the agreement of the 15th of March from tendering or contracting for the sale of the insulators without the plaintiffs' consent. His lordship also held that the plaintiffs, besides giving the usual undertaking as to damages in consequence of the injunction, must in pursuance of clause 4 of the agreement, undertake to give the defendants opportunity for tendering to any railway company or person desiring to purchase the insulators, and that such consent must not be unreasonably refused.

CITY NOTES.

Western Union Telegraph Co.—The directors have decided to "pass" the usual quarterly dividend. The surplus on the 1st July was $4,309,833. The net revenue in the quarter which will end on the 30th inst. (including the earnings during July, August, and September) are estimated at $1,200,000; and, after deducting sums for interests and the Sinking Fund, the balance is $5,366,218. The President's report states that the cable business at the prevailing low rate has increased largely.

West African Telegragh Company, Limited.—The Stock Exchange Committee has appointed Friday, September 17th, as a special settling day for this company's scrip of £300,000 five per cent. mortgage debentures, to which also a quotation has been granted.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending September 10th were £2,432 after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending September 10th were £3,116.

NEW PATENTS—1886.

11401. "Vacuum air pumps, the valves of which are or may be operated by electro-magnetic devices." A. B. WORTH. Dated September 8. (*Complete.*)

11413. "Electric safety lamp for use in mines." M. SETTLE. Dated September 8.

11429. "Electrically working or controlling from a distance the slides of magic lanterns, or in other lanterns for theatrical and other effects." C. LEVER. Dated September 8.

11487. "Making positive pole plates for secondary batteries or accumulators." S. FARBAKY, S. SCHENCK. Dated September 9.

11499. "Telephonic apparatus chiefly designed for transmitting sound vibrations existing in or communicated through the earth." H. H. LAKE. (Communicated by D. Drawbaugh.) Dated September 9. (*Complete.*)

11506. "Switches and working appliances for electric currents." R. A. SCOTT. Dated September 9.

11512. "Collectors or brushes used in electrical locomotion." H. BARCROFT. Dated September 10.

11529. "Electric apparatus for curing special impotence in males." F. BORSODI. Dated September 10. (*Complete.*)

11551. "Telegraphing by means of a system of photo-telegraphy." W. LUCAS, T. A. GARRETT. Dated September 11.

11574. "Electric gas lighters." J. STEVENSON. (Communicated by M. Dick.) Dated September 11.

11611. "Connecting parts of electric conductors." T. F. WALKER, J. G. W. FAIRBAIRN. Dated September 13.

11612. "Electrical switches or apparatus for making and breaking electrical circuits." T. F. WALKER, J. G. W. FAIRBAIRN. Dated September 13.

11634. "Instruments for measuring electric currents." J. C. SERGEANT, R. E. GEORGE. Dated September 13.

11653. "Voltaic electric batteries." R. H. COURTENAY. Dated September 14.

11660. "Telephonic instruments." A. J. BOULT. (Communicated by J. C. Riett.) Dated September 14.

11662. "Telephonic instruments." A. J. BOULT. (Communicated by J. C. Riett.) Dated September 14.

11686. "Arrangements for electrically lighting railway trains." I. A. TIMMINS. Dated September 14.

11693. "Telegraphic apparatus." H. H. LAKE. (Communicated by M. G. Farmer.) Dated September 14. (*Complete.*)

11694. "Electric lamps or lighting apparatus." H. H. LAKE. (Communicated by J. I. Clapp.) Dated September 14. (*Complete.*)

11709. "Electrical cut-outs." E. PERRETT. Dated September 15.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1885.

11120. "Improvements in telephonic apparatus." S. P. THOMSON. Dated September 18. 8d. The transmitter constructed according to the invention is designed to be held in the hand or other suitable support and to work in any position. One or more rods, tubes or pieces of platinum, brass, coke-carbon or other suitable good conductor of electricity are arranged in loose contact in a frame to which the corresponding contact pieces of suitable material are attached or the frame itself is made of contact pieces suitably joined and adapted to receive the rods tubes or pieces, the frame being light, and constructed preferably of wood, ivory, ebonite or any light and not readily breakable substance, or it may be of glass, cork, India-rubber carbon or of metal, solid or hollow, suitably insulated. The vibrations of sounds may be received either through the air direct upon the rods, tubes or pieces, or immediately through the substance of the frame from the sounding body. Claims:—1. A telephonic transmitter constructed substantially as described and adapted for use in the manner specified. 2. The telephone transmitters constructed as illustrated in the figs. 3. Induction apparatus for telephones constructed in the manner substantially as and for the purpose described. 4. The application to telephones of an induction apparatus consisting of a coiled primary wire and a coiled secondary wire the coils being laid side by side in any suitable number and being bound together by iron wire substantially as described. 5. An induction apparatus for telephones consisting of a primary wire around which are longitudinally arranged secondary wires the cable produced being coiled or wrapped upon itself and bound with iron wire either before or after coiling or wrapping and the wires being connected substantially as described. 6. In a telephonic system the combination of a transmitter and an induction apparatus both constructed or arranged substantially as described.

11153. "Improvements in treating wines and liquors with electricity and in an apparatus for the purpose of carrying out same." E. J. FRASER. Dated September 19. 8d. The improvement is based on the discovery the inventor has made that by placing new wine or liquor within the field or influence of an electric coil, or a coil or helix formed like the helix of an electro-magnet and connected with a battery, an electric or magnetic condition is developed and obtained in the liquid which, if continued, will in a comparatively short space of time greatly improve the qualities of the liquor and produce in it many points and qualities that under the ordinary handling and working of liquors are only acquired by age. The claims are five in number.

11265. "An improved appliance for facilitating the transmission and reception of telephonic sounds." H. A. KENT. Dated September 22. 8d. The object of my invention is to combine apparatus for the transmission and reception of sound by telephone, with a chair, couch, or seat, or the like, thus obviating the necessity and inconvenience of using the hands for holding the receivers to the ear, or of having to move to speak to the transmitter. Claims:—1. The combination of a chair, couch, seat, or the like, and telephone transmitting or receiving instruments (or both), substantially as described. 2. A chair, or the like, and telephone transmitting and receiving instruments, or apparatus, combined and arranged as described and illustrated in the drawings. 3. For, or in combination with a chair, couch, seat, or the like, a telephone receiving and transmitting instrument or apparatus, which is adjustable and fixable substantially as described and illustrated in the drawings.

CORRESPONDENCE.

Arc Lamp Patents.

To set Mr. Brockie right as to the state of the art in May, 1883, when he secured his British patent covering "a magnetic brake controlling an iron disc," given by him, in your issue of August 20th, as anticipating the Wenzel electric arc lamp described in the preceding issue, I beg to call his attention to United States Letters Patent No. 221,918, granted to Alfred G. Holcombe on November 25th, 1879, which describes and illustrates an arc lamp having a solenoid or axial electro-magnet, the moving iron core of which, by magnetic inductive action, is caused to rotate an iron disc of the feeding device, to form the arc between the carbon rods, and to act as a brake thereto when the current flowing through the solenoid is decreased by abnormal resistance in the arc.

The application of this principle was made in a more simple manner by causing the iron core of the solenoid to act directly on the upper carbon holding rod made of soft iron, as shown in Mr. Holcombe's patent 249,047, dated November 1st, 1881.

I enclose copies of these patents.

Alfred Shedlock.

New York, *September* 3*rd*, 1886.

[We have forwarded the above-mentioned specifications to Mr. Brockie.—EDS. ELEC. REV.]

An Electrical Experiment.

On January 14th, 1884, I made, in the School of the Technological Trade Museum here, the following novel experiment, and I published an account of it in the *Oesterreichisch-Ungarische Post* (a special Journal which appears here), No. 10, March 5th, 1884.

If anyone stands upon an insulated stool, rubs his hands together and then touches with one hand the collector plate of the gold leaf electrometer the leaves at once diverge, showing that the hand presented is electric. Further examination with a Bohnenberger electroscope showed that *both hands* always become positively electric.

As this remarkable fact, in spite of its publication, has become known to few persons only, I take the liberty of requesting you to publish the above experiment in your esteemed journal, and to introduce its discussion.

Thanking you most courteously in advance for your kindness, and begging you to excuse the trouble I am occasioning, I subscribe myself, with the greatest esteem,

Heinrich Discher.

Vienna, *September* 10*th*, 1886.

[The experiment seems on the face of it to be a somewhat remarkable one, but our correspondent does not state whether he satisfied himself that his hands were not charged positively before he rubbed them together, or whether the stool was really thoroughly insulated.—EDS. ELEC. REV.]

The Chemical Action in the Upward Battery.

I see in your last week's issue that Mr. Crawley still maintains that the chlorine does not act as a depolariser and that no hydrogen can come into the question. I submit the following solution which appears to me the simplest method of showing the chemical reactions. Writing at first Cl_2 Zn and O H_2 for Zn Cl_2 and H_2 O we have

	Porous cell.		Outer cell.
1.	Zn, Zn ; Cl_2 Zn ; O H_2	‖	2 Cl C.
2.	Zn, Zn Cl_2 ; Zn O ; 2 H Cl	‖	C.
3.	Zn ; Zn Cl_2 ; Zn Cl_2 ; H_2 O	‖	C.

Thus the chlorine becomes a depolariser and combines with the hydrogen to form hydrochloric acid, which again acting on the oxide of zinc, forms chloride of zinc and water. No free hydrochloric acid is produced as Mr. S. Walker expects, except, perhaps, a small portion which escapes combination in the outer cell.

By far the greatest chemical action takes place where the carbon is in contact with the porous cell.

R. Frederick Yorke.

Llandudno, *September* 14*th*, 1886.

The Cost of Primary Batteries.

In reply to Mr. Tremain's letter in your last issue, expressing surprise that in your article of the 3rd inst. on this subject, no reference was made to the amount necessary to set aside for interest, depreciation of plant, supervision and maintenance, I am instructed to state that :—

Interest.—It is entirely a matter of opinion what sum should be set aside for interest on plant.

Depreciation.—Five per cent. on the cost of the batteries would be an ample allowance.

Supervision.—None was required after the batteries were installed.

Maintenance.—The cost may be taken at 16 shillings per week for proportion of men's wages, to which must be added the cost of chemicals and zincs, which has already been quoted.

E. C. Davis, *Secretary,*
THE RAILWAY AND DOMESTIC ELECTRIC LIGHTING COMPANY.

London, *September* 14*th*, 1885.

As one who has had practical experience of the Holmes-Burke battery, I am able to give accurate details which may be of interest to your readers. The particular information is arranged as a reply to the seven questions asked in Mr. N. G. Thompson's very sensible letter in your last issue.

The installation at Wybaston House, Lee, Kent, consists of 15 20-volt 10-C.P. lamps taking 1 ampère each, the current being supplied by 17 cells, but in this particular case I am taking only nine lamps which were run from one charge of the battery (17 cells) for 4 hours per night for 5 nights. The result came out as follows, viz. :

1. Working cost equals 32 watt hours per one penny, this price including the total charge used, the cells working until they failed to give the necessary potential at lamp terminals.
2. Output in watt hours 180.
3. Total hours 20. Mean current 9 ampères.
4. Time. Worked 4 hours a day for 5 days.
5. Weight of 17 stoneware cells when charged, about 6 cwt.
6. No fumes.
7. Cost per cell including chemicals, and mercury for zincs, 45s. 6d.

The above charges represent the actual cost to the consumer, as I am of opinion that it is unfair for any inventor of a primary battery to quote cost of maintenance at manufacturers' prices.

If a fuming solution had been used, the output would have been 10 per cent. more, and by reducing the number of lights at the end of the 5 days it is possible to run 6 lamps for another 4 hours on the following day.

If Mr. Thompson wishes, I can show him privately that it is possible to obtain more than 45 watt hours at a cost of 1d.

William Webster, jun., F.C.S., A.S.T.E., &c.

50, Lee Park, Lee, S.E.,
September 15*th*.

[In statement 2, does not our correspondent mean ampère hours ?—EDS. ELEC. REV.]

J. PIGG.—Your proof of the Wheatstone bridge principle is, as you state, the same as that given in Kempe's Handbook of Electrical Testing.